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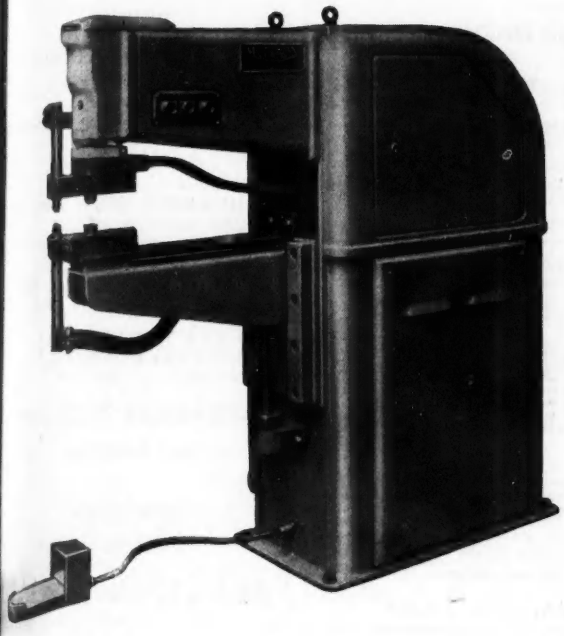

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THE ENGINEER

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BRITAIN AND EURATOM

The International Conference on Radio-isotopes is now drawing to its close in Paris. Nearly a thousand persons from all over the world have listened to papers which, though dealing with apparently diverse subjects, have been related by their reference to a common tool. People from both sides of the iron curtain, and from outside the theatre of the cold war, have gathered amicably to discuss both the newest techniques and the developments of the slightly less new ones. The conference has presented a remarkable illustration of the fertility of international discussion on the essentially a-national fundamentals and methods of science. One is led inevitably to contrast the success of such meetings with those of the politicians, and to wonder whether international concord is not more likely to result from the collaboration of engineers and scientists than from the disputations of diplomats! It has been urged before now that the best route to political harmony is by way of co-operative works and projects designed to serve common interests, and that the gradual accumulation of such enterprises, each on a relatively small scale, may lead to the crumbling of some of the less desirable barriers between nations. Perhaps nowhere else in the world is there a more suitable situation for such combinations of effort than in Western Europe, the source of modern industrial civilisation. It may be, indeed, that some of the architects of organisations such as the Coal and Steel Community and Euratom are inspired as much by idealistic hopes, perhaps even for future political union, as by the prospect of the more material gains resulting from integration.

Whether aspiration runs as high as this or not, and whether or not such an aspiration is laudable, the benefit to be derived from joint enterprises in the European community is probably not greatly questioned to-day. It is therefore understandable that so much has been written and said recently about the attitude of this country to these enterprises, and that some criticism has been levelled at the Government for its cautious approach to the Common Market and Euratom. There are would-be good Europeans among us to-day who would have us throw in our lot with the six countries simply as a gesture of goodwill, however expensive such a gesture might be, and however ephemeral its effect. Fear of possible competition from a federated Europe at some time in the future, and perhaps a pessimistic view of our own abilities, has also produced a crop of arguments, not all as well considered as they might be, favouring the total abandonment of identity and the merging of national in Continental policies "before it is too late." The industrial potential of Western Europe exceeds that of our small island, and independent prosperity for this country has, indeed, so we believe, small hope of enduring alongside the colossus to come unless the economy of this country is linked, by the setting up of a Free Trade Area, to that of the European Common Market. But it does not seem to us to follow as a logical necessity that we should join Euratom. Nor can we give much weight to worried voices uttering suspicion of American motives and fearing that atomic "aid" to Euratom may be the thin end of a commercial wedge to exclude us from this market. For our part, we view the political discussion with caution, though we are perhaps a little bolder in our estimation of what are the material facts. First, it is worth emphasising a point that seems to have been to some extent overlooked, that is, that the United Kingdom is already playing a substantial part in international research activities and the like. Collaboration with other countries in atomic projects is already a fact, and it can both continue and grow without any surrender of sovereignty. The "three wise men" of Euratom, in their report last May, made allusion to their contact with the U.K. Atomic Energy Authority, and expressed as much hope of fruitful co-operation with Britain as with any other state. We have little doubt that there would be the same willingness in this country to assist with Euratom projects as with the individual national projects in which Britain is already interested.

A clearly formulated programme, using existing resources to the best advantage, has been carried through in this country to give us a clear lead in gas-cooled, graphite moderated, reactor technology. It may well be questioned whether we should be wise to sacrifice this gain, and also our freedom to advance along the lines we have chosen, or may wish to choose, as being most suited to our needs. The co-ordination of

policy among nations is difficult. Individual interests are often hard to reconcile with one another. An international programme would be a compromise, and might be weak and ineffective ; there is no certainty that, if ever it were finally resolved upon, there would be a net gain for this country, even in the very long run. The subordination of British to Euratom policy would be a heavy price to pay for so indefinite a prospect. It is also worth while here to draw a distinction between scientific and commercial know-how. Atomic power has become a matter of big business, and much capital has been sunk in the new enterprises. New techniques have been evolved and refined by these undertakings, and many of them are no longer communicable, either because they cannot be transmitted by means of blue prints and manuals, or because they are the legitimately guarded secrets of individual houses. While governments can sponsor fundamental research, both separately and in collaboration, the exploitation of scientific discoveries is a matter for engineering firms working in a commercial world. Even when Western governments combine, their policy is put into practice by such firms, and the British consortia can play a good part in this context. Viewed in this light, the situation may not appear so dangerous as has been argued. It can be maintained that British markets are unlikely to suffer if Britain remains benevolently on the fringes of Euratom. In any event, three-quarters of this country's trade is outside Europe. Euratom is engaged for the time being with the Continental power problem ; the purchase, rather than the export, of nuclear equipment is the present concern of the organisation. In fact, the sextet may offer better promise as our customer within a Free Trade Area than as six-sevenths our master in Euratom. All praise is still due to those who arrange and participate in international scientific conferences. Internationally planned and executed research, and frequent exchange of fundamental information, are not only valuable, but may, as in Sir John Cockcroft's opinion, be imperative. Science has no trade secrets—at least, none that can be kept for long—and the success of international meetings such as the present one in Paris is a good to be desired and sought after. We would join Sir John in his congratulations to Unesco on its considerable achievement in this respect.

SECTION G

Section G of the British Association for the Advancement of Science seldom attracts many engineers to its meetings and few eminent engineers attend them. Furthermore, quite a high proportion of the papers presented are out-of-date, in the sense that they merely repeat information already published elsewhere. In these two respects we believe Section G is exceptional, for other sections appear to do better. But Section G is in itself exceptional. It can almost be said to be the " odd one out " within the Association. The other sections relate either to " pure " science or to the application of a pure science in some practical field, as, for example, in the application of biological discoveries to the improvement of the farmer's crops. But engineering is a technology and most of its discoveries are made within it by engineers themselves. For this reason, so it seems to us, it is far more difficult for the proceedings of Section G to accord with the purposes of the Association as a whole than for those of other sections to do so. The objects of the annual meeting of the Association have recently been defined, broadly, by its Assistant Secretary, Mr. J. M. Robertson. They are to offer a platform on which leading scientists can discuss their work in all its theoretical complexity ; to encourage scientists in joint session to discuss problems in related fields ; and to provide for non-specialists (that is scientists outside their own field, or laymen) an annual stocktaking in intelligible language. It can be said, we think, that if Section G does any of these three things at all it does them very imperfectly.

As Section G is part of the British Association for the Advancement of Science, it is reasonable to expect that the papers presented before it shall relate particularly to the more scientific side of engineering, that is to work carried out in universities and research laboratories. But, unfortunately, it is only very seldom that information about any new discoveries or developments can be presented before Section G. For a theoretical study or research cannot usually be timed to be completed so conveniently that a paper can be prepared for a B.A. meeting. In addition, the various engineering institutions provide very much better platforms for engineers to " discuss their work in all its theoretical complexity " than does Section G. Indeed, discussions at Section G meetings, though delightfully informal, fall far below the technical standards set by Institution meetings. On this ground we do not think Section G at all satisfactorily meets the first of the Associatin's objects as listed by Mr. Robertson. Nor does it get very far in meeting his second object, that of encouraging scientists to discuss problems in joint sessions. At Dublin, for example, there was only one joint session, with Section M (Agriculture). It seems to be rare for a physicist, a chemist, a mathematician, or an economist to be asked to present a paper before Section G on some subject likely to be provocative to engineers. As for the third and last object listed by Mr. Robertson, that of providing for non-specialists and laymen an annual stocktaking in intelligible language, we doubt its practicability. The difficulty arises because engineering is a technology rather than a science. Scientists, if they will take the trouble, can often make themselves intelligible to laymen. The scientific evidence can be summarised and scientific conclusions can be drawn without entering into the complex and confusing detail that only the specialist can appreciate. But within a technology it is very seldom that interesting broad conclusions can be drawn and the detailed observations upon which those conclusions are founded have little or no interest for laymen. For in a technology it is the detail which is important. There has to be an intimate understanding of how materials and structures behave. Fundamentally, a modern locomotive differs hardly at all from one built over a hundred years ago. A broad description of how it works suitable for presentation to a lay audience would apply just as well to the old as to the modern locomotive. To understand why the modern one is " bigger and better " it is necessary to enter into intimate detail about valve gear char-

The Engineer
100 Years Ago
(SEPTEMBER 18, 1857)

" GREAT EASTERN "

" The launching of the Great Eastern is occupying more than ordinary attention. The Great Eastern is about one-eighth of a mile in length, and more than twice the length of the Great Britain, which, a dozen years ago, was the largest iron ship then built or thought of. But her breadth (83 feet) is much less in proportion to her length (680 feet) than that of the vessel just named (the length of which is 322 feet, and her breadth 51 feet), a point of difference which affords the best ground for the anticipations entertained of the speed with which she will cross the Atlantic.

" The most prominent feature about the great ship is the cellular construction of the upper deck, and the lower part of the hull, up to the water line, or about thirty feet from her bottom, which is flat. This system increases her strength enormously, and will enable her to resist almost any amount of outward pressure. Two walls of iron, about 60 feet high, divide the vessel longitudinally into three parts, the inner containing the boilers, the engine-rooms, and the saloons, rising one above the other, and the lateral divisions the coal bunkers; and, above them the side cabins and berths. . . . The weight of this huge ship being 12,000 tons, and her coal and cargo about 18,000 tons more, the motive power required to propel her twenty miles per hour must be proportionate. The screw shaft is 160 feet in length, and weighs 100 tons ; this extends from the engine-room nearest the stern to the extremity of the ship. The paddle-wheels are driven by four engines, having a nominal power of 1,100 horses, and the screw by a nominal power of 1,600 horses. The screw engines were designed and manufactured by Messrs. James Watt and Co., are the largest ever constructed, and when making fifty revolutions per minute, will exert an effective force of not less than 8,000 horses. The four cylinders each weigh about twenty-five tons, and are eighty-four inches in diameter."

acteristics, steam flow through ports, gas flow through tubes, blast pipe orifices, and the like, most of it incomprehensible to laymen. It is not at all easy to present such detail in easily comprehensible form.

Thus, Section G proceedings hardly seem to conform at all closely to the professed objects of a B.A. meeting. The organisers of Section G have given its programme a "set" form to which it nowadays annually conforms. One can be critical of that "set" form and one can point out that the objects of the Association do not seem to be at all closely met by it. But it is not at all easy to see what changes would certainly be for the better. Objections can be seen to almost any suggestion. The Section President, for example, might be encouraged to present an address of general interest rather than of interest only to engineers. But we confess it is a tall order to ask anyone to provide something which would deeply interest engineers and still be comprehensible to laymen. Another suggestion is that technical sessions should predominantly relate to research work being done in the locality of the meeting, a thing already arranged to some extent. But would not a consequence of too great an emphasis upon that arrangement be that only specialists would be attracted to any given annual meeting, the very reverse of what the B.A. aims to do? More topicality might be introduced by ensuring that at least one lecture or paper covered some engineering subject that had excited the public mind during the previous twelve months; but one cannot guarantee there will be any such subject! What does seem to be essential is that Section G meetings should acquire a flavour peculiarly their own and to be experienced nowhere else. Section G cannot compete in its technical proceedings with those of major engineering institutions and no one wants it to come down solely to a forum for presenting popular accounts of engineering to laymen. The first and third objects of the Association seem, indeed, almost beyond hope of adequate attainment. But surely the second is in a different category. At no other meetings could physicists, chemists, biologists, economists and other scientists so appropriately combine in joint discussions with engineers. Section G proceedings would acquire a peculiar flavour of their own if scientists in various fields were asked to present papers or lectures to engineers showing how their work might be applied or in what way engineers could help their sciences, and if, in the more technical sessions, attention was concentrated upon fields in which engineers and other scientists are jointly active. Cross fertilisation of ideas might thereby be encouraged even though informal discussion failed to reach a high technical standard.

A Seven Day Journal

National Industrial Fuel Efficiency Service

THE third progress survey of the National Industrial Fuel Efficiency Service covering the period for the twelve months up to March 31, 1957, was presented at a meeting held on Tuesday of this week under the chairmanship of Sir Leslie Hollinghurst, who mentioned that the income of the service had been guaranteed for a further five years. The survey recalls the efforts to arouse interest in fuel efficiency followed by the introduction of heat and power surveys and, in the current year, the development of regular service agreements and the beginnings of a specific advisory service. A diagram shows the allocation of engineering time, of which 54·7 per cent was fee-earning, and a table allocates the regular service agreements to various industrial groups and shows that the number increased from 262 in the previous year to 426. Heat and power surveys are called the backbone of the work of the service and the time devoted to this service increased by 14 per cent over the previous year. A table indicates the distribution of this work among the industrial groups and another table includes the average fuel savings possible, the overall average being 18·4 per cent. Such returns are considered to confirm earlier estimates that total possible savings of up to between 7,000,000 to 10,000,000 tons of coal can be achieved.

Another fact revealed by the survey is that the work has become more comprehensive in that reports relating to combustion and process combined have doubled. Another section of the report is concerned with efficiency of Lancashire boilers, and the results of tests with and without economisers clearly indicate room for considerable improvement. Of the boilers tested without economisers, over 90 per cent did not attain a reasonable target efficiency, and in 71·5 per cent the flue gas temperatures were above 550 deg. Fah, the corresponding figures for boilers with economisers being 94 per cent, with 39 per cent having flue gases exceeding 450 deg. Fah. In some 45 per cent of all boilers it is recorded that the CO_2 content of the flue gases did not exceed 6 per cent. An overall average efficiency of 62·5 per cent is quoted and compared with the progress made by the Central Electricity Authority—that is, from 69·5 per cent in 1920 to 89·7 per cent in 1955. Tabular statements set forth an analysis of the Government loan schemes giving class of consumer and type of scheme together with the amount of loans and the coal saved or replaced. The survey concludes with notes upon how fuel is saved and quotes specific examples for various industries.

Royal Aeronautical Society

THE Royal Aeronautical Society held its Garden Party on Sunday last at Wisley. Highlight of the flying display was the appearance, appropriately on the anniversary of the Battle of Britain, of a Hawker "Hurricane," "The Last of the Many," and a Supermarine "Spitfire," the oldest remaining Mk. V. The aerobatics of the "Spitfire" held the attention of all, and its demonstration culminated in turning inside the "Hurricane" when the bigger fighter "attacked" it at low speed. The light aircraft flown included the recently restored English Electric "Wren," with a 349 c.c. engine, and aircraft using modified automobile engines based on the Volkswagen and water-cooled Ford 1172. Foreign aircraft were numerous and interesting, one of the most pleasing to see being the butterfly-tailed Beechcraft "Bonanza." On the ground were other light aircraft, including a J.A.P.-engined "Aeronca," and one amphibian; strangely on a Vickers aerodrome, this was a Grumman "Albatross." A static exhibition featured a Supermarine "S.6b" racing seaplane, less engine, and several of the smaller aircraft of the first two decades of this century. A collection of models, some of excellent workmanship, was on view; particularly complete and consistently labelled was a set of Armstrong Whitworth machines ranging from an "Atlas" to an "Albemarle." Outstanding was a power-driven flying scale model of a 1910 Bristol racing biplane.

Freezing Fish at Sea

THE trawler "Northern Wave" was chartered by the White Fish Authority for a series of experimental voyages in the first half of 1956, and an installation designed to freeze the catch at sea was tried out. The investigation was completed by shore tests on various methods of handling and distributing the fish landed by the "Northern Wave," and the task was concluded by the end of 1956. The Authority has now published a report describing the trials and their results. The main conclusions state that the technical practicability of the method has been demonstrated. Whole white fish can be frozen at sea in a converted modern distant-water trawler under all weather conditions, the report claims, and the operation can be carried out by members of an ordinary fishing crew. For the most part, the trade is said to have agreed that the thawed fish is suitable for filleting, smoke curing, handling and distribution by the normal methods, but at times the typical "bloom" of first-quality iced fish is thought to have been lacking in the experimental catches, and some of the fish from some voyages did not smoke well. The report is less definite in assessing the economics of the process, but it is suggested to be probable that, if fish were stored at times of short supply, the higher prices received would normally cover the higher costs of production and storage.

The trials were sponsored jointly by the Government, the Distant Water Vessel Owners' Development Committee, and the White Fish Authority. The D.S.I.R. did some of the preliminary work, and took part throughout in the supervision of the tests. The net cost of the experiment was £109,500. Of this sum, £87,000 was spent on converting and restoring "Northern Wave." The trawler was returned to the owners without the freezing plant because, it is stated, certain technical reasons made it inadvisable to retain the installation for commercial use.

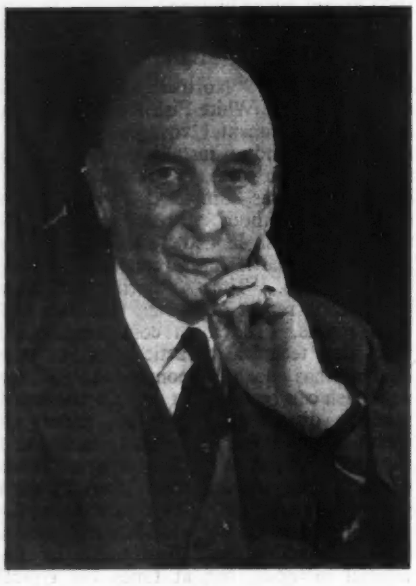
The report on the experiment is in three parts. The first is a general account, with a summary of the conclusions reached, and is available separately for 6d. The second part, prepared by the D.S.I.R. and the Authority, deals with technical aspects of the experiment, and the third part contains figures and tables illustrating the subject matter of the second part. The full report, entitled *Report on an Experiment into the Freezing of Fish at Sea*, costs 5s. Copies of the full report or its first part may be obtained from the White Fish Authority, Tilbury House, Petty France, London, S.W.1.

Obituary

VICTOR A. PATTERSON, C.B.E.

We record with great regret the death of Mr. Victor Alexander Patterson, of Bexley, Kent, which occurred in the Middlesex Hospital, London, last Friday, September 13. Mr. Patterson, who was seventy, was deputy chairman and managing director of J. and E. Hall, Ltd., Dartford, and had completed forty-six years in the firm's service.

Victor Patterson was born in Belfast and was educated at Oundle School. After leaving school in 1904, he began a seven-year pupilage with W. H. Allen, Sons and Co., Ltd., at Bedford. Mr. Patterson joined the staff of J. and E. Hall, Ltd., in 1911, his first appointment being that of assistant works manager; two years later he became works manager of the refrigeration department. Although the manufacture of refrigeration equipment was the principal part of the firm's business at that time, one section of the works had for some years been engaged in the production of heavy motor vehicles. About 1912, the War Office instituted a system of subsidies for privately-owned commercial vehicles, which had to conform to a uniform specification and pass a series of rigorous road tests. The subsidy was, of course, paid on the understanding that the vehicles would be available for use in the event of war. The lorries built by Hall's qualified for the subsidy, but before the Government's scheme was fully operating the first world war had started. Arrangements had to be made for the production of the maximum possible number of motor vehicles. In addition to his responsibilities in the refrigeration equipment department of his firm, Mr. Patterson undertook much of the organisation essential to the stepping up of motor vehicle output to meet wartime demands.



V. A. Patterson

A few years after the first world war, J. and E. Hall, Ltd., discontinued its motor vehicle production business. Progress in the development of refrigeration machinery was rapid, and, in addition, the firm took over the business of Medway's Safety Lift Company. In the reorganisation required to deal with this development, Mr. Patterson joined the board of J. and E. Hall, Ltd., as works director in 1925; he was appointed deputy chairman and managing director in 1949.

During the whole of the forty-six years which he spent with J. and E. Hall, Ltd., Mr. Patterson took a special interest in the welfare of the company's employees, and the many amenities available to all who are employed at the Dartford Ironworks have resulted largely from his initiative and enthusiasm. But Mr. Patterson's ability and energy as an engineer and administrator were by no means restricted to his company. His record of service to the engineering industry generally, and in public affairs, is impressive. For many years Mr. Patterson had taken an active part in the work of the Engineering and Allied Employers' National Federation. He was a member of its management board and had served on many of its committees, including the negotiating committee. He was also a past-president of the Federation's London and District Association. Other services to industry included the chairmanship of the committee for the area set up by the London and S.E. Regional Board for Industry, the presidency of the North West Kent Industrial Fire Brigades Association, and the chairmanship of the Industrial Association of North West Kent.

In the county of Kent and especially in the neighbourhood of Dartford, there were numerous public offices which Mr. Patterson gladly performed. They were concerned with hospitals, sports associations and other cultural and social organisations. In 1948, Mr. Patterson became president of the local unit of the Sea Cadet Corps and set up its training centre, the T.S. "Anson." Mr. Patterson was also a Justice of the Peace of the County of Kent. As a mark of appreciation of his many services, he was made the third Freeman of the Borough of Dartford in 1953. Last year Mr. Patterson was created a C.B.E., and only a month or so ago he was appointed a Deputy Lieutenant of the County of Kent.

There are many people within and outside the engineering industries who will mourn the death of Victor Patterson. For some time his health had been deteriorating, but his zeal and enjoyment of work and service to the community remained undiminished. His personality and his life's work will long be remembered.

L. H. DANIEL

Mr. Leslie Henry Daniel, whose death occurred last Saturday, September 14, had been director of the National Coal Board's central engineering establishment since its inception. He joined the Coal Board's staff in 1954 in order to set up an organisation for the improvement and development of equipment for the mining industry.

Mr. Daniel, who was fifty-one, was educated at the Woolwich Polytechnic, and subsequently graduated at the Queen Mary College, Mile End, where he carried out one year of post-graduate research for his M.Sc. degree in electrical and mechanical engineering. In 1928, Mr. Daniel began a student apprenticeship with The British Thomson-Houston Company, Ltd., and when that was completed in 1931, he was appointed to the laboratory staff of the British Electrical and Allied Industries Research Association. From 1939 onwards Mr. Daniel's work with the E.R.A. was concerned with a variety of Government contracts.

Just after the war, in 1946, Mr. Daniel joined the Ministry of Supply as a senior principal scientific officer, and in 1949 he was appointed deputy chief engineer of the Vehicles Research and Development Establishment. His duties there included the design and development of fighting vehicles to the production stage, as well as the direction of specialist branches dealing with engines, transmissions, electrical equipment and armour. During his term at the establishment, Mr. Daniel was closely associated with the development work on the Centurion tank.

As already mentioned, Mr. Daniel joined the staff of the National Coal Board in 1954. The decision to build a central engineering establishment had then been recently taken by the Board, and the site at Bretby, in South Derbyshire, had been acquired. The principal function of the establishment is to develop new coal mining machines and techniques and to improve existing methods and techniques. It also engages in the preparation of technical specifications and designs of new machines to enable alternative sources of manufacture to be exploited. In addition, the establishment is equipped to carry out acceptance trials of mining machinery in the prototype and production stages. The task of setting up the organisation required for this kind of work became the responsibility of Mr. Daniel. Last year was the first full year of the establishment's operation, the work being concentrated mainly on the development of improved power-loading machines and tunnelling and drilling equipment. The nature of some of the work carried out under Mr. Daniel's able direction is described in an article on the establishment which was printed in The Engineer of December 21, 1956.

GERALD STEEL, C.B.E.

The death of Mr. Gerald Steel, which occurred on Saturday last, September 14, in London, deprives the British steel industry of one of its leading executives. He was general managing director of The United Steel Companies, Ltd., and president-elect of the British Iron and Steel Federation.

Mr. Steel, who was sixty-three, was educated at Charterhouse and Oriel College, Oxford. Throughout the first world war he served with the Royal Fusiliers and the King's African Rifles in East Africa, and entered the steel industry following demobilisation in 1919. He joined Steel, Peech and Tozer, in Sheffield, a firm which his father helped to found. In 1928, Mr. Steel was appointed managing director of The United Steel Companies (India), Ltd., and worked for four years in India. He returned to this country in 1932, becoming a director and the general manager of Samuel Fox and Co., Ltd., another of the companies in the United Steel Group. In 1941, Mr. Steel was appointed to the board of The United Steel Companies, Ltd., becoming joint managing director in 1947, sole managing director in 1949, and general managing director in 1954.

For a number of years Mr. Steel had been active in the work of the British Iron and Steel Federation, serving on its council and executive committee. His special interest was in that part of the Federation's work related to education and training in the steel industry; he was the first chairman of the Federation's training committee. Mr. Steel was also a member of the British Steel Producers' Conference, chairman of the central council of Iron and Steel Employers Associations, a vice-president of the Iron and Steel Institute, and a director of the National Provincial Bank. He was created C.B.E. in the New Year Honours of 1956.

Seals for Roll Neck and Roller Table Bearings*

By H. N. WILKINSON, B.Sc. (Eng.)

An investigation has been made into seals for roll neck and roller table bearings in steelworks. The report discusses the special problems involved and surveys the various types of seals available, indicating their suitability and the main requirements for their efficient operation. The lip seal, the type most widely used, is dealt with in detail. It is concluded that a properly designed lip seal will give reasonably good service under all but the most arduous conditions, but careful attention to detail is necessary. The use of other types of seals, such as mechanical seals, labyrinths and slingers, either in combination with lip seals or even in certain instances to replace them, should be considered.

IT is hardly necessary to emphasise the importance of having efficient seals for rolling mill plant, which needs to operate continuously for long periods without costly delays due to breakdowns. Because of the extremely heavy loads which must be carried, the roll neck bearings can be regarded as the heart of any rolling mill, and as such demand careful attention. Seals are necessary to retain lubricant in the bearing and prevent the entry of water and scale, or rolling oil. In view of the wide variety of rolling mills operating in this country, some being as much as forty years old, it cannot be expected that there is any one generally applicable solution to the sealing problem. Rather, the requirements for each mill must be studied separately. In any particular case the most suitable sealing arrangement will depend largely on the type of mill, the bearing, the space available, and the operating conditions.

Roll neck seals evolved as mill and bearing design improved and as operating conditions became more exacting. In early mills having simple grease-lubricated "four-part" bearings, seals were unnecessary. However, in the late 1920's, as bearing loads and rolling speeds increased, roller bearings and fluid film bearings were introduced to reduce power consumption, and suitable seals had to be developed. Many different designs have been tried, some with greater success than others. This paper reviews the various types which are available, with special reference to the lip seal, which has shown itself to have a wider application than any of its competitors. Suggestions are made showing how each kind of seal can best be applied, and in what circumstances satisfactory results may be expected. This is particularly important where it is not practicable to modify the seal housing to accommodate an improved arrangement.

Unless otherwise stated, the text refers to seals for roll neck rather than roller table bearings. However, in actual fact there is a great deal of common ground and it should be clear where the text applies equally well to seals for either type of bearing.

Sources of Information

The information in this paper has been supplied by steelworks, rolling mill and bearing manufacturers, oil companies and oil seal manufacturers. In addition, a survey has been made of published information on sealing and allied subjects. A number of articles exist which are of a purely descriptive nature, although some deal specifically with seals for roll neck bearings. It appears that a fair amount of research has been carried out, mainly on lip seals, packings and O-rings, generally, to discover the effect of the various service factors on leakage and wear. Unfortunately, the results given by the different authors are often confusing and inconclusive, and sometimes contradictory. A few attempts have been made to study the subject theoretically, mainly with regard to mechanical seals. Considerable general information is also available on such subjects as bearings, lubrication and lip seal materials. The conclusion gained from a study of all this published information is that while useful as background knowledge, and also for guidance in application of the present types of seals, it does not make any real suggestions for improvements in the design of sealing systems for roll neck and roller table bearings.

* Communication from the British Iron and Steel Research Association.

The Sealing Problem

Hot Mills.—In these installations the operating conditions are particularly severe: there is the general condition of shock loading, while the high temperature rolled material passing through the rolls is sprayed with jets of descaling or cooling water. The seal must serve the dual purpose of preventing the escape of lubricant from the bearing, and at the same time preventing the entry of water and scale. The greatest sealing problem is caused by the bottom "back up" bearing on a four-high stand, which is often of the fluid film type operating on an oil circulation system.

If a good quality bearing circulation oil is employed, the ingress of water alone does not present a major problem as it can readily be removed by ordinary heat settling at a temperature of 180 deg. Fah., or by centrifuging. However, when iron oxides (e.g. scale) are present, these materials tend to form iron soaps, some of which are soluble in the oil and cannot be completely removed by gravity or mechanical treatment. Emulsions of this nature have quite good lubricating properties, but their viscosity is unpredictable. They may become so viscous that the circulation pumps will be incapable of handling them; insufficient oil is likely to be fed to the bearings and bearing failure may result. Until recently, stubbornly emulsified oils in this condition had to be rejected, but chemical emulsion splitters have been introduced which are capable of splitting the stubborn emulsions formed in rolling mill systems.[1]

Cold Mills.—The operating conditions are much less severe than with hot rolling. Instead of descaling water, a rolling lubricant such as palm oil is used. While the seal must prevent the loss of bearing oil, the greater problem is to prevent the entry of rolling lubricant into the bearing. Rolling oils, which are of a low viscosity to prevent slipping of the work rolls on the strip, must not be allowed to mix with the bearing lubricant, having a much higher viscosity, since the viscosity of the mixture is lowered disproportionately. A mixture of rolling and bearing oils cannot be separated by mechanical means, since their specific gravities are of the same order. Also, a method such as centrifuging is only applicable to immiscible fluids and as both bearing oils and rolling oils are generally of petroleum origin, they are completely soluble in each other and cannot be separated except by redistillation. Since the rolled product is continuous strip, the bearings are under load almost without respite, and it is therefore especially important that the bearing oil is of the requisite viscosity and quality.

Temper Mills.—In these installations the material is rolled dry. The seal has the single function of retaining the bearing lubricant. It is essential that even the slightest drop of lubricant is prevented from escaping from the bearing and staining the rolled product.

Breast Rollers and Roller Tables.—The conditions under which the breast roller and roller table bearings operate will be much the same as those for the attendant mill. The breast roller bearings on a hot slabbing mill, in particular, will be subject to very heavy shock loads, and the attendant conditions of high temperature, scale and high-pressure descaling water will also be present. The scale may be in large-sized flakes, which would very soon ruin most forms of rubbing seal unless these were protected in some way. However, seals for roller tables should not constitute a very serious problem, especially on hot continuous mills, cold mills and temper mills.

The function of the seal is to prevent abrasive materials entering the bearing, causing wear and increase of the clearance. Escape of lubricant is, of course, also to be avoided. The bearings used are either of the roller or the plain metal type, usually lubricated by grease on a total-loss system. Unfortunately, these bearings and their seals are often allowed to run for long periods without inspection or maintenance, as concontrasted to the roll neck bearings which inevitably receive periodic attention due to the frequency of roll changes and the accepted necessity of inspecting this class of bearing at regular intervals.

Types of Bearings

The type of bearing used has a considerable influence on the type of seal required.

Plain Metal Bearings.—These are found on the older types of rolling mills. They are grease lubricated, often from a mechanical forced feed system. Usually the egress of grease from the bearing is relied upon to prevent the entry of water and scale, and no seals are provided.

Fluid Film Bearings.—The two main types are the "Morgoil" and the Robertson "Flood Lubrication Bearing." An oil circulation system is necessary, which includes the pump, heater, centrifuge, cooler, filters and settling tanks. It is with these bearings that the greatest sealing problem arises. They are used extensively for the back-up rolls of four-high hot and cold strip mills, and also for two-high mills.

Roller Bearings.—The two main types are the Skefko spherical roller bearing, and the Timken taper roller bearing. Their most usual application is for the work rolls of four-high hot and cold strip mills. These bearings are generally lubricated from a mechanical centralised greasing system. In some instances many of the grease connections may be left disconnected so as to speed roll changes, the

bearings and seals depending for their lubrication on the prepacking on assembly in the shops. The function of the lubricant is to minimise metallic contact between the rollers and their cages, and to protect the accurately ground and highly polished surfaces from corrosion. In addition, the lubricant aids the dissipation of heat and in sealing the bearing against intrusion of contaminants.

Fabric Bearings.—These bearings are becoming increasingly popular. Water alone, water with grease, or an oil and water emulsion serves the dual purpose of lubricant and coolant to the bearings. The large quantity of water used tends to prevent scale entering the bearings, and hence it is usual to dispense with seals.

Requirements of an Effective Sealing Arrangement

Ease of Fitting.—One of the most important factors affecting the performance of a seal is the facility with which it can be fitted and replaced. A seal which is difficult to fit is always liable to be badly fitted and become damaged, although this risk should be less where spare sets of bearings and chocks are available and the seal can be fitted without undue haste. Unfortunately, the facility with which a seal can be fitted and examined afterwards is often largely influenced by the design of the chock and seal housing, which it may be impracticable to alter.

Robustness.—As a corollary to the previous requirement it follows that the seal must be sufficiently robust. Roll changes may occur frequently, and while in some installations the seals are not disturbed during this operation, in many cases they are liable to be damaged. In addition, the seal must withstand the very severe operating conditions associated with rolling mill plant.

Compactness.—The space available for the seals is severely limited. A decrease in the diameter of the roll neck or an increase in the distance between the bearing and the end of the roll would not be possible owing to the high stresses already involved. Therefore the sealing arrangement has to be made as compact as possible. This is one of the major difficulties which designers of roll neck seals have to face, since the requirements of robustness and ease of fitting, on the one hand, and compactness at diameters of up to 48in, on the other hand, are not readily satisfied.

Reserve Capacity.—The sealing arrangement on a roll neck bearing should consist of a combination of seals. This is a most desirable feature, for two reasons. First, a seal which is effective in preventing the escape of lubricants may not be so effective at preventing the ingress of contaminants and vice versa. Hence it is better to fit two seals, each to serve its particular purpose. Secondly, in view of the serious consequences arising from seal failure, the bearing should be doubly protected. Then, if one seal fails, the other, while probably not wholly effective, will at least prevent serious leakage.

Types of Seals

Many different kinds of seals are available, some being more suited for application to rolling mill plant than others. A brief survey follows, indicating where each type should be used and the main requirements for its efficient operation.

Three main subdivisions can be made, as follows.

Seal by Bearing Design (Figs. 1 and 2)

This type of seal is restricted to ball and roller bearings. Two types are available:

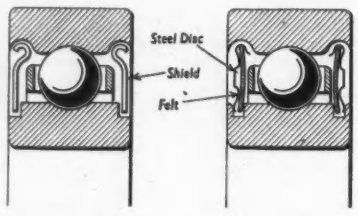


Fig. 1—Shielded ball bearing

Fig. 2—Self-sealed ball bearing

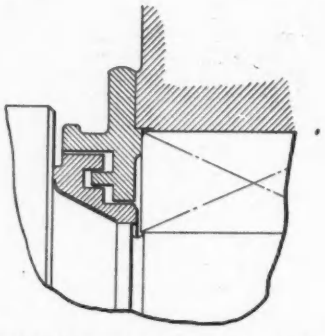


Fig. 3—Labyrinth seal fitted to roll neck bearing

the self-sealed bearing which incorporates a felt washer and steel protecting disc in its construction, and the shielded bearing which incorporates a sealing disc only. It would appear that these could usefully be used on roller tables.

Non-Rubbing Seals

The advantages of this group of seals are many. Since there is no rubbing, there is no frictional resistance and wear. They are generally non-adjustable, and therefore require no attention. Being made of metallic materials, as contrasted to a class of rubbing seal made of synthetic rubber, they are unaffected by proximity to high temperature and other adverse conditions. The main disadvantages with non-rubbing seals are that they all depend to some extent on speed for their action, and complete sealing cannot always be guaranteed. They are best utilised in combination with a rubbing seal in order to ensure efficiency of operation.

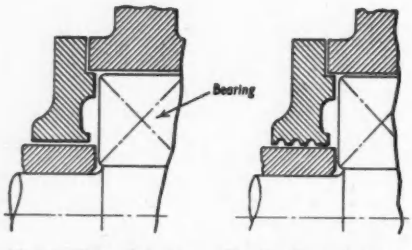


Fig. 4—Plain clearance type seal

Fig. 5—Grooved clearance type seal

Labyrinths (*Fig.* 3).—Labyrinths are more effective for sealing grease than oil. It is desirable that grease should be fed into the labyrinth during operation to prevent the ingress of water and scale. It is considered that this type of seal could be more widely used with bearings operated on an all-loss pressurised grease lubrication system, especially with ball and roller bearings. In the form shown in Fig. 3 it is only suitable for installations where the bearing and seal can be fitted over the end of the shaft, not where the bearing must be assembled in the split form around the shaft.

Plain and Grooved Clearances (*Figs.* 4 *and* 5).—The efficiency of this type of seal depends on the clearance between the shaft and the housing flange being as small as possible, without risk of interference through eccentricity or bearing wear. The flange should be as long as possible for efficient sealing. When small annular grooves are machined in the housing flange, a greater degree of sealing is effected. When used with oil, these annular grooves have the effect of breaking the capillary action, and where grease is the lubricant the packing of grease in the grooves makes a close seal. The possible application of this seal on rolling mills is rather limited. It might be usefully incorporated in roller table bearing housings to prevent the ingress of the majority of the scale and water.

Spiral Grooves (*Fig.* 6).—The spiral groove may be regarded as a screw pump, driving any oil that has crept along the shaft back into the housing, and the handing must be chosen accordingly. For obvious reasons it should not be used where the direction of rotation is reversed.[2] Nor would it be suitable where water and scale or rolling lubricants are present, since there would be the undesirable effect of these contaminants being driven into the bearing. It might be usefully employed to prevent the ingress of undesirable matter into a grease-lubricated roller table bearing, but in all applications sufficient space must be available to allow for an effective length of spiral grooving.

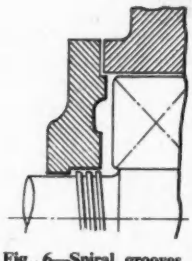
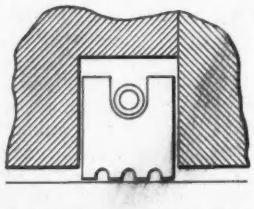


Fig. 6—Spiral grooves as a seal

Slingers (*Fig.* 17).—Oil slingers depend upon centrifugal force for their action, and they are therefore only suitable for sufficiently high-speed applications. They are most commonly used adjacent a fluid film bearing which has considerable end leakage. A slinger ring is sometimes welded on to the end of the roll to prevent the bulk of the descaling water or rolling lubricant coming into contact with the other seals. An alternative system is to provide a groove at the end of the rolls. Both systems are effective. The only bearing design incorporating a slinger is the latest type of "Morgoil." It has been found so effective in retaining oil in the bearings that on temper mills no other seal is necessary. A further advantage is that the slinger acts as a baffle and prevents oil being projected directly on to the lip seals. It is suggested that a double slinger having edges outwardly flared in either direction to divert the oil and water into separate annular channels should be developed.



Ring, either in two halves or with single split, may be located by pin to prevent rotation.

Fig. 7—Piston ring seal

Rubbing Seals

Lip Seals (*Figs.* 8 *to* 15).—This is the type of seal most frequently used on roll neck bearings. It consists of a flexible annular member held in close contact under spring

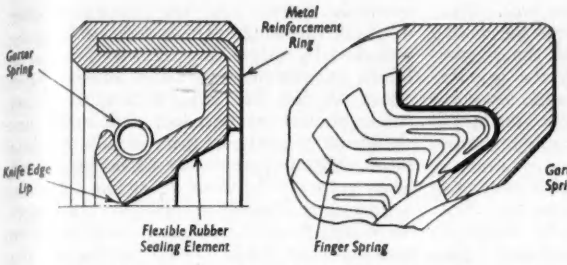


Fig. 8—Lip seal with garter spring

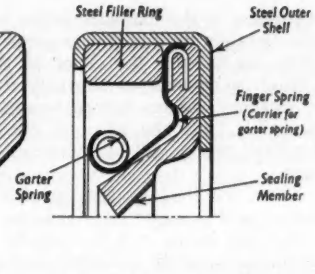


Fig. 9—Split seal with finger springs

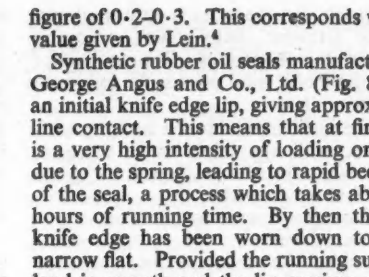


Fig. 10—" Garlock " roll neck seal

load against the rotating shaft. It will be dealt with in greater detail later.

Mechanical (or Face) Seals (Figs. 16 and 17).—These are used on the roll necks of hot mills to provide a simple water seal. A lead bronze ring is pressed against the end of the roll by the action of a number of springs around its circumference. On such large diameters these seals alone cannot be relied upon to protect the bearing. A perfect mating surface between the seal ring and the end of the roll is difficult to achieve, and when obtained would be hard to maintain under the arduous conditions prevailing. Moreover, scale is liable to get in between and separate or wear the surfaces. However, this type of seal serves a useful purpose in preventing the bulk of the water and scale from coming into contact with the less robust lip seals. Further developments with this seal might be possible on the smaller cold mills where large particles of scale are not present.

Piston Ring Seals (Fig. 7).—This seal usually consists of a bronze ring fitting snugly in an annular housing. It is considered effective on both roll neck and roller table bearing applications. The main disadvantage is that great care and accuracy in fitting is required, since to be effective when sealing oil, very small clearances are necessary.

Packings.—Although widely used for other applications, this type of seal is hardly suitable for roll neck bearings. Packings are sometimes used for sealing bearings on roller tables.

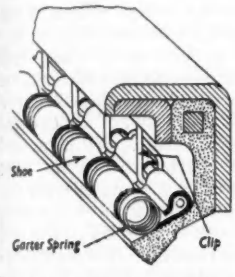


Fig. 11—" Burflex " seal with " shoe " type spring carrier

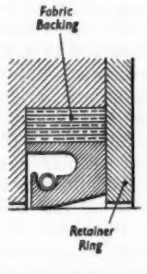


Fig. 12—Typical mounting arrangement for the " Walkersele "

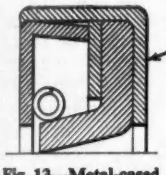


Fig. 13—Metal-cased " tin-can " seal

Fig. 14—Double-lipped seal

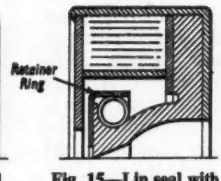


Fig. 15—Lip seal with retainer ring

Lip Seals

Method of Operation.—Very little has been written on the theoretical aspects of lip seal performance, although practical work has been done by T. C. Scott,[3] J. Lein,[4] and others, to discover how various factors affect the operation of the seal. Rig tests have been largely used, and relatively small seals, from 6in in diameter downwards, employed. It is difficult to judge how far results obtained on small-sized seals are valid when applied to seals having a diameter of up to 48in. Other aspects of lip seal operation are discussed in a paper by E. W. Fisher,[5] and much useful information has been given to the author by Mr. E. T. Jagger, of George Angus and Co., Ltd. His researches have shown that provided the seal is lubricated a very thin oil film exists between the lip and the running surface or " land," even though considerable pressure may be exerted on the lip by the garter spring or by other means. Experiments conducted to determine the value of the coefficient of friction at the seal lip gave a figure of 0·2–0·3. This corresponds with the value given by Lein.[4]

Synthetic rubber oil seals manufactured by George Angus and Co., Ltd. (Fig. 8), have an initial knife edge lip, giving approximately line contact. This means that at first there is a very high intensity of loading on the lip due to the spring, leading to rapid bedding-in of the seal, a process which takes about two hours of running time. By then the initial knife edge has been worn down to a very narrow flat. Provided the running surface or land is smooth and the lip receives sufficient lubricant, there is little further lip wear under ideal conditions. When wear does occur it is due to abrasive dirt becoming lodged under the lip. Wear itself is not detrimental, since good sealing is possible after a considerable amount has taken place. Rate of wear is vital, and when it is high particles of abraded rubber will hinder the efficient operation of the seal.

The lip causes a track to be worn on the land. Tests have shown that on a mild steel land of 12–15 micro inches surface finish, a thin, highly polished band of 2–4 micro inches finish is soon formed. At the same time the lip itself attains a very high quality surface finish, which could otherwise only be obtained at considerable additional expense during manufacture. For this reason, when the lip of a bedded-in seal and its running surface are parted, good results can only be expected on reassembly when the seal lip is arranged to run over exactly the same track as previously.

Construction.—The lip seal unit consists essentially of a flexible annular member held in close contact under spring load against the rotating shaft. Large-sized seals require some form of additional stiffening or backing in order to give sufficient rigidity to allow the seal to be handled and fitted without difficulty. A wide variety of designs exist, but the basic principles of all are the same. In the majority of cases the seal assembly forms one unbroken circular unit which has to be fitted over the end of the shaft. Split seals are also made, which can be fitted without major disturbance of other parts. Two forms of split seal are available. In the simplest form the seal unit is split in one place only and it is flexible enough to be passed round the shaft. A more ambitious design is supplied by Charles Weston and Co., Ltd. This seal is made in two rigid and exactly semi-circular halves with provision for a perfect butt joint to be formed between the halves when installed.

Sealing Element.—The most important detail of the assembly is the sealing element. Materials normally used are synthetic rubber,

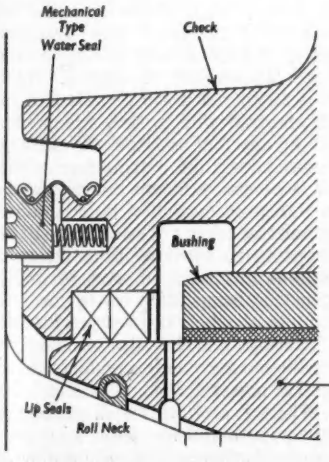


Fig. 16—Seal housing in bearing chock

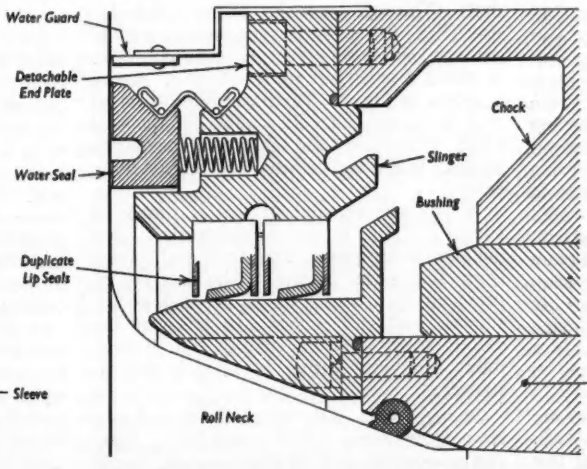


Fig. 17—Sealing arrangement for Morgoil bearing

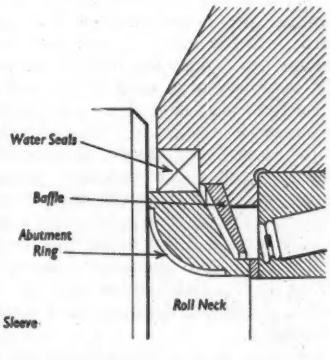


Fig. 18—Abutment ring fitted to roll neck bearing

leather or felt, but the latter is only employed on small diameter shafts where operating conditions are not arduous. The material of the sealing element must possess the following properties :

(*a*) Flexibility, to enable the lip to remain in contact with the land under eccentric running conditions and to adapt itself to the slight surface irregularities.
(*b*) Resistance to wear by abrasion.
(*c*) Tear resistance.
(*d*) Resistance to hardening due to heat and oil.
(*e*) Resistance to change in volume and weight due to heat and oil.

These requirements are met reasonably well by synthetic rubber, which has, in addition, a certain amount of elasticity. The properties of synthetic rubber can be varied over quite a wide range by the inclusion of additives in the " mix." Considerable experience and specialised knowledge are required in order to determine the most suitable " mix " for any particular application. Operating temperature, land speed, eccentricity, lubricant or liquid to be sealed and its pressure, presence of abrasive particles, seal housing dimensions, are all factors which need to be considered when deciding on the exact composition of the material for the sealing element.

While less frequently used than synthetic rubber, leather still has certain advantages. It will give better service when the seal runs on a land not possessing a good surface finish, or where little lubricant reaches the lip, or where the type of lubricant used is liable to be changed. However, it is generally agreed that for conditions of high speed and temperature synthetic rubber is superior. Leather must always suffer from the disadvantage that, being a natural product, its consistency cannot be guaranteed. Moreover, it is found that the porosity of leather, an advantage when little lubricant reaches the lip, often tends to increase and become a liability, so that oil seeps through the seal. However, a number of special leathers have been developed recently. " Protosil," used by Charles Weston and Co., Ltd., is claimed to retain its original properties for a considerable time. The National Motor Bearing Company has introduced a " Micro-Torc " leather seal in which chrome retanned leather is coated with a mixture of dry lubricant and elastomeric material. The elastomer binds the dry lubricant and prevents oil leakage through the leather.

Lip Loading.—The major part of the load on the lip is provided by the spring, which may be either a garter spring (Fig. 8) or a series of finger springs (Fig. 9). An interesting combination of both is incorporated in the " Garlock " seal, manufactured under licence in England by George Angus and Co., Ltd. (Fig. 10). Here the finger springs also serve as carriers for the garter spring, preventing the embedding of the individual turns into the relatively soft material of the sealing lip. Another method of achieving the same object is used in the Burtonwood " Burflex " seal (Fig. 11). The garter spring is housed in a series of " shoes " mounted in clips around the inside face of the seal. Garter springs are generally preferred to finger springs, being much cheaper and more robust. The finger springs can easily snap during careless fitting of the seal but they are still used on split seals where damage during fitting is less liable to occur, and where a garter spring joined with hooked ends may be unsuitable.

Lip seals are manufactured so that they are initially an interference fit on the shaft. Before the fitting of the garter spring, this interference is of the order of ½in-¾in, according to the diameter of the seal. This ensures that the sealing lip grips the shaft, quite apart from the effect of the spring. Owing to its lack of elasticity the grip of a leather sealing element soon becomes negligible, but the grip of one made of synthetic rubber will be appreciable for some time.

Thus, the load on the lip of a synthetic rubber seal is made up of two parts : that due to the spring and that due to the interference afforded by the sealing element. The reason the whole of the lip load cannot be supplied by the rubber sealing element alone is due to the gradual deterioration and loss of elasticity of that material when exposed to high temperatures. During the life of the seal the load due to the rubber material gradually decreases until it becomes zero, while that due to the spring remains substantially the same, provided a good quality spring is used. Non-corrodible springs can generally be supplied if required. On the other hand, if too much of the original load is supplied by the garter spring and there is insufficient interference, a bulging or " looping " of the lip may occur. Synthetic rubber seals without springs are manufactured, but it follows that they can only be effectively applied where the rubber will not be subjected to conditions which cause rapid ageing and loss of elasticity. It is common practice to keep the lip load at a practical minimum, consistent with the lip maintaining contact with the land under eccentric conditions. In this way heating, deformation and wear of the lip and scoring of the shaft are reduced.

Another method of providing lip loading has been tried on an aluminium foil rolling mill, where seals are required to retain the bearing lubricant and keep out the rolling coolant. Air at a pressure between 10 lb and 15 lb per square inch is supplied between the two lip seals, which are arranged to face one another. The air pressure provides the load on the lip, garter springs being dispensed with. At the same time, should the lip of the outer seals become damaged, the escape of air at once makes this fact obvious and also helps to keep the roll coolant out of the bearing. This system has proved very effective, resulting in a 50 per cent saving in consumption of bearing oil.

Rigidity.—Sufficient rigidity for a large-sized seal may be supplied in a number of ways. The metal-cased or " tin-can " type of construction (Fig. 13) serves a number of purposes. It provides a backing for the sealing element and gives it some protection. Moreover, the metal case is made a press fit in the seal housing, thereby preventing both the escape of lubricant around the outside of the seal and the rotation of the seal with the shaft. The steel outer shell of the "Garlock" seal (Fig. 10) gives less protection to the sealing element but serves the same purposes. A more simple, but quite effective, system is shown in Fig. 8. The metal reinforcement ring is bonded into the rubber of the seal itself. This makes the seal much cheaper to produce and it can be fitted and refitted quite easily.

A very simple kind of seal is shown in Fig. 12. This is the " Walkersele." No metallic components are employed, apart from the garter spring. The backing is provided by a cotton fabric proofed with a suitable synthetic rubber. In this way the seal is given sufficient rigidity, yet its flexibility simplifies fitting in certain circumstances.

Storage.—Lip seals should be stored at a temperature between 50 deg. and 70 deg. Fah., and exposure to extreme cold avoided. A cold atmosphere tends to harden both leather and synthetic rubber and may lead to some difficulty in fitting. This condition may be remedied by suspending the seal for ten to fifteen minutes in clear, warm mineral oil at about 100 deg. Fah. prior to fitting. Excess stocks should be avoided, and new consignments of seals are best stored to allow those delivered previously to be used first. Seals must not be wired or strung together, neither must they be tipped into containers or loosely heaped : lack of care in these respects may cause damage to the sealing lip. It may be convenient to store the smaller seals by fitting them over a tube of the appropriate size, but a roughly finished or over-sized tube might cause damage to the lip or stretch the seal, resulting in premature permanent set.

Fitting.—The importance of observing the correct procedure when fitting a lip seal into its housing, and the chock on to the roll neck, can hardly be over-emphasised. Perhaps the greatest failing of a lip seal, particularly one made of synthetic rubber, is the ease with which the all-important sealing edge can be damaged. Even a slight scratch will cause the seal to leak. If spare sets of chocks are available, the fitting of seals can be carried out without undue haste. Seals are best fitted into the chocks or end plates with the axis of the seal and chock in a vertical position, but the chock is fitted on to the roll neck with the axis horizontal. It is preferable to offer the chock to the roll, rather than the roll to the chock.

The metal-cased type of seal requires to be carefully fitted. It is necessary to ensure that the housing bore has been accurately machined to allow the correct interference, and a good finish is essential. Should the interference be insufficient, it may be found that a seal which fits perfectly well while the chock is cold becomes a loose fit when the chock has warmed up under operating conditions. Special attention must be paid when the metal case and the seal housing are of unlike materials, with unequal coefficients of expansion. However, the metal cases of roll neck seals are normally made of steel, as are the chocks, and this problem does not arise. It is also important that a true concentric relationship is established between the bore of the seal housing and the bearing. The housings for seals having bonded-in metal reinforcement rings, or having a simple fabric backing, should be prepared similarly, although the same degree of finish will not be necessary.

Metal-cased seals have to be handled with care to avoid scratching the surfaces which mate with the housing bore, and to avoid bending the seal from its truly circular shape. Otherwise, leakage around the outside of the seal may occur, and difficulty will be experienced when fitting it into position. When pressing the seal into its housing a firm uniform pressure should be exerted. This operation is facilitated if the outside face of the seal is smeared with grease, which also helps to fill up any tool marks in the housing bore, or scratches on the outside face of the seal. If it is necessary to tap a large metal-cased seal into position with a hide hammer great care must be taken. The seal must not enter the housing in a tilted position. Damage to the seal lip is most likely to occur when the bearing chock is being fitted on to the roll neck (or on to the bearing sleeve with the Morgoil bearings). The lip should be smeared with grease, and shoulders over which the seal passes should, if possible, be rounded. The roll neck itself will, of course, be perfectly smooth and free from scratches. Under most circumstances a lip seal is almost equally effective whichever way it faces:

therefore the seal, or both seals in a duplicate arrangement, should generally be fitted to face in whichever way is least likely to cause damage to the lip during the assembly. The practice of one firm of lip seal manufacturers who send a fitter to a new customer, thereby ensuring that the technique for fitting that type of seal is fully understood, is to be commended.

No advantage is gained with synthetic rubber seals by any form of soaking in oil prior to assembly, except in the circumstances previously mentioned. If some time is going to elapse after assembly before lubricant reaches the sealing lip, smearing the lip or land with oil or grease will generally suffice.

An interesting problem which arose at a certain steel works was due to the difficulty experienced when fitting the seals into the bearing chocks, shown in Fig. 16. It was necessary to remove both the tapered sleeve and the bushing before the seals, which were of the metal-cased type, could be fitted. The seals had to be carefully tapped into position in the most inaccessible part of the chock. Moreover, once the bearing had been reassembled the seals were completely hidden and could not be inspected. The problem was largely solved by substituting flexible "Walkerseles" for the rigid metal-cased type. These seals could be fitted quite easily after the bearing sleeve only had been removed. The bushing remained untouched.

Initially some difficulty was experienced in devising a method of mounting the "Walkerseles" in position. The method normally recommended (Fig. 12) is to employ a retainer ring, which exerts a slight axial nip on the seal. In addition, the seal is always moulded a little oversize, offering a further safeguard against leakage around the seal. However, in this particular application there is clearly no room for any such retainer ring. This difficulty was overcome in an interesting way. The inner of the two seals was manufactured having a number of studs equally spaced around its outside face, so that the seals are nipped between the end of the housing bore and the end of the bushing.

An almost identical problem occurred at another steel works, but it was tackled in an entirely different way. Similar bearings and chock arrangements were involved, with the exception that the running surface for the seals was provided by a shoulder on the roll neck, and not by the bearing sleeve extension. Metal-cased seals were used, and fitting was again the difficulty. Moreover, it was suspected that seals sometimes became dislodged when the chock was fitted on to the roll neck, and forced back into position during the reverse procedure. The problem was solved by redesigning the end of the chock. The existing seal housing was removed and a detachable end plate housing the lip seals and a mechanical type water seal was substituted. In this way the seals could be fitted into the end plate, which could in turn be bolted on to the chock, without dismantling the bearing.

There appears to be little scope for the use of split lip seals on roll neck bearings. The clearance between the bearing chock and the end of the roll is comparatively small, and it is hardly possible to devise a system which will allow the seals to be changed without first removing the chock from the roll neck, thereby losing the one advantage which split seals possess. However, where flexible seals having the single split are to be used, the split should be arranged at the top. If duplicate seals are fitted, the splits should be staggered. Extra care must be taken to ensure that the seals are firmly held in the housing.

Operating Conditions.— The way in which the operating conditions differ between each of the main classes of mills, and the respective function of the seals, has been referred to previously. The capabilities of the existing types of lip seals, with special reference to the rubbing speed, temperature, pressure to be sealed and eccentricity, will now be discussed.

Various figures are quoted for the maximum rubbing speeds and temperatures which synthetic rubber and leather seals will handle satisfactorily. A figure given by one manufacturer is 3500ft per minute, but 3000ft per minute is a more usual value. The maximum suitable operating temperature will depend on the rubber "mix," but 250 deg. to 300 deg. Fah. is about the limit. It must be appreciated that at these high temperatures synthetic rubber ages much more rapidly, and the life of the seal is reduced accordingly. Therefore, every attempt should be made to ensure that the temperature is kept to a minimum. It is hoped that with the development of silicone rubber, lip seals operating at temperatures far in advance of these figures will be possible. Unfortunately, at present the mechanical properties of this new material are not all that could be desired, the tear resistance and the resistance to abrasion in particular being very much lower than those for normal synthetic rubbers.

Leather seals must operate at rather lower speeds and temperatures than those permitted for synthetic rubber. Average maximum values quoted for leather are 2000ft per minute and 200 deg. Fah. For both types of seals these maximum values are attainable only if the lip is adequately lubricated and the land has a suitable surface finish. This will be discussed later.

While it is useful to know the range of temperature over which a seal will give satisfactory service, in practice it is very difficult to determine exactly what the temperature at the seal lip is in any particular installation. When testing seals on a rig the problem is somewhat simplified. The method used by Stott[5] was to sink the hot junction of an iron-constantan thermocouple into the surface of the revolving land, the leads being taken to two sliprings and thence by brushes to the recording potentiometer. His results showed that the temperature at the lip is much higher than that of the oil circulating through the bearing. However, as a rough guide to the operating conditions at the roll neck, figures quoted by Dr. L. R. Underwood[6] may be of interest. For hot mills in which the neck is cooled by large quantities of water, he gives the temperature as 120 deg. Fah., and up to 160 deg. Fah. or even higher if the water supply is less copious. The land speeds on rolling mills range up to 3000ft per minute, and in special cases even higher.

Standard lip seals are not designed to withstand pressure, their purpose being to prevent the seepage of liquid along the shaft, and when acting in this capacity the seal is almost equally effective whichever way it faces. However, it is possible to use lip seals for pressures up to about 30 lb per square inch. They must be installed so that the pressure being sealed acts in conjunction with the garter spring to supply an extra load on the lip. While standard seals can be used in this way for pressures up to 5 lb to 10 lb per square inch, specially designed seals must be used if this figure is to be exceeded, otherwise the extra load on the lip could cause excessive friction and heating. The pressure of the oil supplied to a fluid film bearing is about 10 lb to 15 lb per square inch, but by the time the oil has circulated and emerged at the ends, its pressure will have been greatly reduced. The temperature is about 80 deg. to 100 deg. Fah.

It is a great advantage if some form of baffle can be arranged to prevent the oil emerging from the ends of the bearing impinging directly on to the seals. This is particularly important when the work enters the rolls, because at this instant the journal and the bearing are suddenly pressed together, thereby causing much of the lubricant in between to be squeezed into a jet towards the seals. Such a baffle is provided by the slinger fitted to the latest type of Morgoil bearing (Fig. 17). An alternative system is to mount the seals on a shoulder on the roll neck or on an abutment ring, at a different level to that of the bearing surface (Fig. 18).

A major factor affecting the performance of a lip seal is the amount of eccentricity which it must accommodate. This will be due in part to the distance between the centres of the bearing and journal. In addition, the bearing and the housing of the seal may not be concentric, while the greatest eccentricity of all is often due to lack of roundness of the shaft itself. For practical purposes the effective eccentricity can be regarded as the sum of all three eccentricities.

Due to the very small clearance, the eccentricity of a roller bearing will be quite small. A greater problem exists where fluid film bearings are used. While the nominal clearance is usually about 0·001in per inch of bearing diameter, in practice it is often considerably in excess of this figure, and it is not uncommon for the clearance to reach 0·002in per inch of diameter, before the bearing is relined. This means that a seal fitted to a 30in diameter roll neck may have to accommodate an eccentricity of 0·060in or nearly $\frac{1}{16}$in. The amount of eccentricity which can be accommodated before the seal starts leaking depends on the speed of rotation and whether shock loading is liable to occur. A graph showing the performance of an Angus lip seal is shown in Fig. 19. At 100 r.p.m., a typical speed for a rolling mill, the maximum permissible eccentricity would be 0·022in.

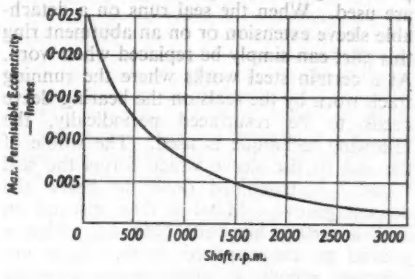


Fig. 19—Speed-eccentricity graph for lip seal shown in Fig. 8

It is claimed that the "Garlock" seal (Fig. 10) which has been specially designed for roll neck bearings, can accommodate eccentricities up to $\frac{3}{32}$in in certain instances, while the Burtonwood Engineering Company claim that the "Burflex" seal (Fig. 11) is capable of giving efficient sealing for eccentricities up to $\frac{1}{16}$in. It may be noted that both these seals are provided with means to prevent a garter spring embedding itself into the rubber sealing member, and therefore a much more powerful garter spring than is normally possible can be fitted. However, the relationship between the lip load and ability to accommodate eccentricity is not known.

Another way of tackling this problem has

been tried by Super Oil Seals, Ltd. A retainer ring is clipped on to the garter spring after the seal has been assembled on the shaft, thereby ensuring that the lip retains its truly circular shape under all conditions. This seal is shown in Fig. 15.

Land Surface.—There are certain factors affecting the performance of a seal which just have to be accepted and the seal designed accordingly. Rubbing speed, temperature, pressure to be sealed and eccentricity largely come within this category and have been dealt with previously. However, there are certain other conditions which may be wholly or partly within the control of the operator.

With roll neck bearings the rubbing surface or land for the seal may be either the roll neck itself, a shoulder on the roll neck, the bearing sleeve (Fig. 16), a detachable bearing sleeve extension (Fig. 17), or an abutment ring fitted on to the neck (Fig. 18). In the first three cases the choice of land material will be governed primarily by considerations other than the requirements of the seal, but in the last two it should be possible to provide the material which makes the best rubbing surface for the seal. While there is no doubt that steel of some kind is the most suitable material, there is quite a wide divergence of opinion regarding the hardness of surface required. One seal manufacturer states that ordinary commercial mild steel is perfectly satisfactory, and that hardened surfaces need only be considered where abrasive materials are likely to be present. The Brinell hardness number (B.H.N.) of mild steel is approximately 130. However, the majority of seal manufacturers recommend a hardened land in all circumstances. Values quoted are from 220–280 B.H.N. upwards.

The need for a sufficiently hard land arises from the tendency of lip seals to wear a groove in the running surface. This is particularly marked where seals fitted with powerful garter springs giving high lip loads are used. When the seal runs on a detachable sleeve extension or on an abutment ring this part can simply be replaced when worn. At a certain steel works where the running track worn by the seals on the bearing sleeve needs to be resurfaced periodically, the following technique is used. The whole of the end of the sleeve which forms the seal "land" is machined down to below the deepest groove. Metal is then sprayed on until a surface has been built up, which is ground to the required finish. It is not sufficient merely to spray metal into the grooves and grind a surface, since the slight crevice between new and parent metal would still exist. This resurfacing is necessary every two to three years. Chromium plating must be of the first quality to make a satisfactory land for synthetic rubber. A synthetic rubber seal will eventually dislodge poor quality plating, and the small pieces that are removed will cut the sealing member and destroy it.

It is generally agreed that to ensure good sealing the surface finish of the land should be as smooth as possible, 10 to 20 micro-inches C.L.A. (see B.S.S. 1134) being good enough for most purposes. A leather seal will operate satisfactorily on a less smooth land than would one of synthetic rubber. There is little advantage in obtaining a very high degree of surface finish, since the seal itself soon wears a polished track, but an initial roughness of 40 micro-inches upwards is to be deprecated, especially for synthetic rubber. A rough surface causes abrasion and rapid wear of the lip. Almost as important as specifying what surface finish is required is the method by which it is obtained. Grinding is preferable to turning and polishing, and plunge grinding should be used rather than traverse grinding, which may give a minute screw effect, causing leakage. A chattering grinding wheel, due to worn machine parts, will cause flats around the periphery of the land.

Lubrication of Sealing Lip.—Adequate lubrication of the lip of the seal is essential to ensure its maximum life and efficient operation. At the same time the lubrication should not be excessive, otherwise leakage may result. When seals are adjacent to the bearings, the bearing lubricant can generally be relied upon to take care of the seals. In isolated locations, however, or when bearing lubricant is prevented from reaching the seals by the intervention of a slinger (Fig. 17), or when seals are arranged in pairs, provision should be made for the seals to be lubricated. Synthetic rubber seals, by reason of their non-porous nature, will rapidly deteriorate if allowed to run dry, and may even discolour the shaft or land. For this reason leather seals, which can be impregnated with a lubricant, are often preferred where little oil or grease is likely to reach the lip. It is common practice for lip seals on roll necks to be arranged in duplicate (Figs. 16 and 17). Lubricant should be supplied between the seals, otherwise the one furthest from the bearing is liable to run dry.

It has been previously stated (page 412) that the type of lubricant to be sealed is one of the many factors which determines the "mix" required for a seal of synthetic rubber. It follows, therefore, that the ideal lubricant to supply to the lip is the same as the one used in the bearing. In this connection special care should be taken when using extreme pressure lubricants, by reason of their chemical additives, which may have deleterious effects on seals unless these have been manufactured with the appropriate grade of material. It follows, therefore, that seals fitted to roll necks having fluid film bearings should be supplied with oil. One modern bearing employs a small pump to supply oil from a source independent of the main circulation system, thereby ensuring that the oil to the seals is free from any dirt picked up in the system.

Notwithstanding what has been written, it is more usual to find that seals on oil lubricated bearings are supplied with grease. Besides being more simple, it avoids the necessity of having to uncouple the oil connections when changing the rolls. Roller bearings fitted to roll necks are almost invariably grease lubricated, as are the seals. Grease may either be pre-packed between the seals on assembly or supplied via a grease-gun nipple. In either case care must be taken to ensure that the space between the seals is not overfilled, since the grease will expand as it becomes warmer under operating conditions. It is recommended that the space should be approximately two-thirds filled.

Particular care must be taken when lubricating with a grease-gun, since a very high pressure can easily be applied. If both lips point towards the bearing and no vent is provided, excess pressure can only be relieved by the grease bursting through the seals. A fairly soft grease should always be used in a grease gun to avoid it being extruded from under the seal lip before the whole of the space between the seals has been supplied. One disadvantage with grease as a seal lubricant is that a build-up of grease near to the lip may well occur: it has been suggested that this acts as a slinger and prevents further supplies from reaching the lip. Double-lipped seals (Fig. 14) are to be avoided where possible. When one sealing lip wears or gets damaged the whole seal has to be discarded, while the only way of lubricating the outside lip is to pre-pack the cavity between the two lips with grease. On cold mills, where a rolling oil is used, lubrication between the seals may not be necessary and double-lipped seals will show to better advantage.

Seal Life.—It is impossible to predict in advance the life of a lip seal, and no seal manufacturer is willing to suggest in a trade publication what life might be expected. Even under the closely controlled conditions of a rig test in a laboratory the properties of a lip seal vary quite widely, and large numbers of tests have to be conducted to obtain representative results. The cause of seal failure may be due either to the combined effects of ageing and wear or to damage of the sealing lip. The latter is most likely to occur during fitting or roll changing.

At one hot mill where duplicate lip seals pre-packed with grease are fitted it is found that the inner of the two inboard seals will give approximately ten times more life than the outer seal from an actual wear point of view. When the running surface of the seals is examined it may be observed that the groove worn by the outside seal is encircled by a thin film of rust. This situation probably arises from the fact that the outer of the two seals comes in contact with descaling water, which tends to wash the lubricant away from the lip, while scale particles penetrate beneath the lip of the seal, causing the extra wear.

Conclusions

No fundamentally new sealing principle has been found. Much of the development work being carried out elsewhere is devoted to adaptations of and modifications to existing types of seals, with in some cases the attendant disadvantage of additional complication.

The lip seal will give reasonably good service under all but the most arduous conditions, but it demands care in fitting, a smooth "land" surface, adequate lubrication of the lip, and a minimum of eccentricity. In other words, careful attention to detail is necessary. It should be "tailor-made" for the job, especially when synthetic rubber is used.

Lip seals would greatly benefit if a material could be produced which was similar to synthetic rubber in most respects, but having a greater resistance to wear by abrasion and to temperature and ageing effects, and having an inherent toughness which would make the lip less prone to damage.

Many of the difficulties experienced when using lip seals are due to imperfectly designed bearing chocks and seal housings which it is impracticable to alter.

A lip seal by itself, or even in duplicate, does not provide sufficient protection to the bearing where abrasive materials are likely to be present. Some other device, such as a mechanical seal, should be used in addition to keep out as much of the scale as possible.

Labyrinths and slingers deserve wider application, either in combination with lip seals or even in certain instances to replace them.

Acknowledgments

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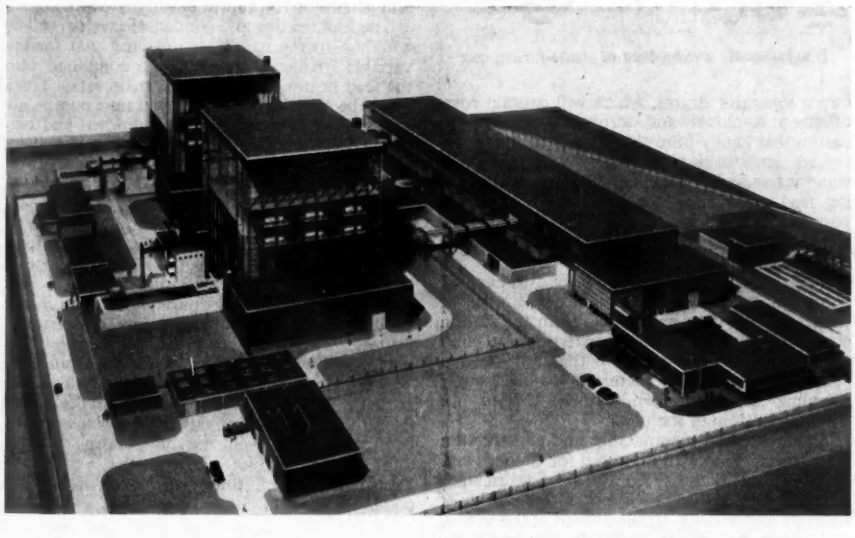
REFERENCES

[1] Chisholm, S. F., "Rolling Mill Lubricants," *Iron and Coal Trades Review*, June 6, 1952.
[2] C. C. Wakefield and Co., Ltd., *Bearing Lubrication*, chapter "Oil and Grease Sealing Devices."
[3] Stott, T. C., "Some Notes on Synthetic Rubber Oil Seal Applications," *Journal, I.A.E.*, July-September, 1944.
[4] Lein, J., "Mechanical Tests on Rubber Sealing Rings for Rotating Shafts," *The Engineers' Digest*, February, 1955, from *Konstruktion*, October, 1954.
[5] Fisher, E. W., "Considerations in the Development of Roll Neck Oil Seals," *Iron and Steel Engineer*, May, 1950.
[6] Underwood, L. R., "Roll Neck Bearings," Part I.

Design for Nuclear Power Station at Hinkley Point

Subject to clearance of certain outstanding matters, the Central Electricity Authority has placed a contract with the English Electric Company, Ltd., in association with Babcock and Wilcox, Ltd., and Taylor Woodrow, Ltd., for the building of a nuclear power station at Hinkley Point, Somerset. The station is scheduled to come into operation by 1962, *and its total cost is estimated to be in the region of* £60,000,000. *The net guaranteed electrical output of the two graphite-moderated, gas-cooled reactors is to be 5MW. A description of the project is given below.*

THE first nuclear power station to be built by the English Electric-Babcock and Wilcox-Taylor Woodrow consortium is designed for a net electrical output of 500,000kW generated at 13·8kV and stepped up to 275kV for feeding to the national supergrid. The station is to occupy 44 acres on the coast near Hinkley Point in Somerset, and its ground plan is said to be no larger than that of current 300,000kW stations. Our illustration, reproduced from the photograph of a model, shows the two reactor buildings with their ancillary structures, the long turbine house with workshop attached, and the control and administration buildings arranged on the three sides of a garden. The steam-raising units and the carbon dioxide blower house are grouped on either side of each reactor building. It is estimated that a total staff of about 300 persons will be required to operate the station.



Model of the projected power station at Hinkley Point. The reactor loads are to be transmitted to the substrata of limestone and shale through individual foundations

REACTORS

The twenty-four-sided core of each reactor, which will contain the fuel elements, and a reflector surrounding the core are to be made of graphite blocks. The structure, held in position by bands round the periphery, is to be contained in a spherical steel pressure vessel, and supported on ball bearings to reduce friction caused by differences in thermal expansion between the metal support plates and the graphite.

The fuel is to be loaded from the top through charge pans which will protect the top face and give a positive location for the charging machinery. Gas seals will control the flow of coolant gas between the graphite structure and the pressure vessel. The core is to be pierced by a lattice of vertical channels through which the fuel elements will be lowered into the moderating blocks, while holes for control rods, flux scanning and irradiation test specimens are to be formed from chamfers at the four corners of adjacent columns. Shock load from the inadvertent dropping of a fuel element or control rod is to be absorbed by special devices. The fuel element supports will have a throttle to vary the gas flow across the core and so help to keep a maximum can temperature over a large part of the core. Graphite temperature is to be measured by thermo-couples.

The 67ft diameter spherical pressure vessel to contain the graphite core is to be welded on site from preformed mild steel plates, 3in thick. The vessel is to be supported on an external cylindrical skirt welded to it, and the bottom of the skirt will rest on structural steel members above the concrete foundation. The graphite structure itself is to be supported on a grid, the weight being transmitted to the external skirt by an internal skirt supporting the grid.

The hot gas will leave the top of the shell through six large circular openings, and there are to be six similar inlet openings in the bottom for the return of the cooled gas. Tubes welded to nozzles inside the vessel will project through the biological shield to enable various operations to be performed, including the charge and discharge of fuel and the insertion of control rods. Thermal insulation is to consist of internal lagging in the upper half of the vessel and external lagging on the lower part. Overheating of the upper part of the vessel is to be prevented by use of a part of the shield cooling system.

Each fuel element will consist of a cylindrical rod of uranium sealed in a can of magnesium alloy to prevent chemical reaction between the uranium and the coolant gas, and also to contain fission products formed during irradiation. The cans, which are to have a finned surface to increase the transfer of heat to the coolant gas, will stand vertically in the channels in the graphite core. The main source of heat in the reactor is expected to be at a relatively high temperature, and a proportion of the elements is designed with thermo-couple junctions for recording of the can temperatures. Temporary thermo-coupled elements are also to be provided to check the performance of the permanent thermo-coupled elements during the initial operation of the reactor. Special elements are to flatten the radial flux distribution across the reactor. Since flux distribution changes under operating conditions, these elements are designed to allow adjustments of the amount of neutron-absorbing material. Further dummy elements containing graphite will be provided for insertion in the topmost position in each channel in order to reduce both neutron leakage from the reactor and the buffeting of the fuel elements underneath by the coolant gas.

If a fuel can were to fail, fission products would escape into the coolant gas and cause an increase in radioactivity. To avoid this, the radioactivity of the gas is to be measured regularly to detect any failure. This will be done by taking samples of gas from each channel through standpipes to selector valves outside the biological shield. Each group of channels will be sampled in this way for a period of twenty-five seconds every thirty minutes. Provision is also to be made for the independent monitoring of suspect channels, and the outlet ducts from the reactor are to be monitored at frequent intervals.

The charge and discharge equipment is designed to allow refuelling while the reactor is pressurised and working at full power. Its principal components are to be (i) a hole preparation machine, and (ii) a fuelling machine for storing new and irradiated fuel, preparing the reactor for fuelling, inserting new fuel, changing the position of elements, withdrawing irradiated fuel from the reactor and disposing of irradiated fuel from the machine to the storage pond. Both machines are to be handled by an overhead crane on top of the reactor. Fuel is to be moved into and out of the reactor through charge tubes which will lead out of the pressure vessel. These tubes are to be pressure-sealed by plugs and cover plates. Each charge tube will serve several channels, and a charge chute will bridge the gap between the end of the charge tube and the particular channel which is being refuelled. The hole preparation machine will carry out the preparatory work necessary to allow the fuelling machine to insert or withdraw elements. The fuelling machine will carry the elements in its magazine, and will have an electrically operated winding gear and pneumatic grab head to engage the fuel elements. It will incorporate its own system for cooling irradiated fuel elements before they are withdrawn from the machine. Interlocks will prevent maloperation and ensure that the correct sequence of operations is followed. Shielding will protect the operators on the pile cap.

Irradiated elements are to be discharged into

the cooling ponds, and when their radiation has fallen to a reasonable level (after approximately three months) they will be transferred to "coffins." These will then be taken to a wash-down area, after which they can be taken away for reprocessing.

The reactor pressure vessel is to be contained wholly within the reinforced concrete biological shield. This is itself to be lined with a thermal shield of reinforced concrete and steel plates. The two shields will be separated by cooling air passages of varying width, so that the thermal shield, with the associated cooling system, will protect the biological shield from excessive temperatures and temperature gradients which would otherwise arise. The continuous flow of cooling air will be discharged to atmosphere through filters designed to stop the passage of any irradiated particles. It will be possible to operate the fans continuously, and there is also to be a standby fan to take over their duty during routine maintenance.

The biological shield will be surmounted by a concrete pile cap perforated to allow the passage of the fuel charge and reactor control tubes vertically into the reactor vessel. Secondary biological shields will attenuate radiation which may escape through the openings for the gas circulating ducts between reactor and plant and equipment outside the main biological shield.

Gas is to be circulated through the reactor and steam-raising unit circuits by axial-flow circulators. The single-stage rotor blading is to be mounted on an overhung disc so that only one shaft seal will be needed. The circular casing, which is to be of the fabricated pressure vessel type, will require only one seal-welded flange seal against pressure in the circulator assembly. The smallest possible change in temperature of the various parts of the plant, in spite of changes in the heat output, is to be achieved by varying the gas flow through the reactor in proportion to the heat output, and this variation is to be obtained by controlling the speed of the circulator.

The main gas ducting is all to be of large diameter. Each boiler will be connected to the reactor pressure vessel by one duct entering the unit at the top. A similar duct at the bottom of each unit will connect to its associated inlet manifold. A blower recirculation duct is to be connected to an intermediate section of the blower discharge, and this duct will be led to the associated steam-raising unit and connected to it between the banks of the lower pressure boiler and low temperature economiser. The main duct connecting each blower back to the reactor is to be taken from the blower discharge.

Air-operated main gas isolating valves are to be placed in each outlet duct between the reactor and steam-raising units, and in the inlet ducts between each blower and reactor. Similarly, isolating valves are to be fitted in each blower recirculation duct. Safety valves will be incorporated at appropriate points in the circuits, and facilities for blowdown are to be provided, as well as exhaust equipment for evacuation of major volumes of gas.

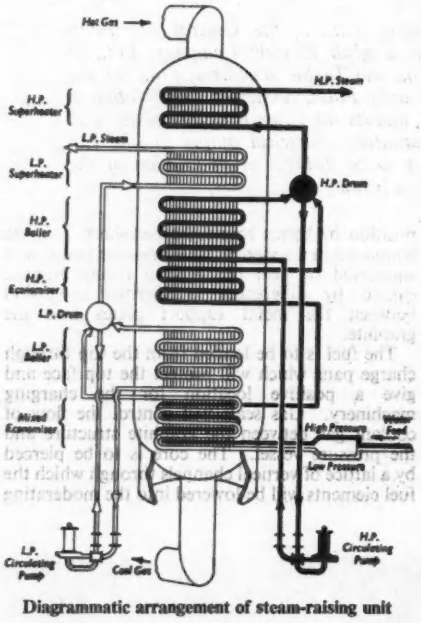
Heat Exchangers

There are to be six Babcock heat exchangers for each of the reactors, and these are to generate in total over 5,500,000 lb of steam per hour, approximately two-thirds of it at a high pressure and one-third at a lower pressure. Like steam-raising units associated with other installations for the Central Electricity Authority programme, these are developments of the double-pressure design for the Calder Hall installation. In the case of the Hinkley Point plant, developments in the properties of the heating surface and in methods of construction and operation are such that each unit is expected to have a capacity three-and-a-half times that of a Calder Hall steam-raising unit, although the height and diameter are only to be 20 per cent and 25 per cent greater respectively.

The main vertical shells of the steam-raising units are to be 90ft high and 21ft 6in diameter, with a maximum wall thickness of 2¾in, and they are to be mounted on skirt supports resting on a concrete base. The whole of the steam-raising plant is to be housed in buildings next to the reactor and fitted with a ladder and gallery system to give full working access to all headers, drums and mountings. Each shell is to contain seven banks of heating surface made up of individually supported, flexible, multiloop, studded elements connected to horizontal external headers through thermal sleeve openings in the shell wall. Each bank of heating surface will be surrounded by baffle plating to direct the gas flow.

The extended heating surface will consist of a multitude of flat studs of elliptical section welded to the tubes, and is to be a development of the Babcock and Wilcox surface formerly used in economisers for marine boilers and at Calder Hall. The heat transfer and pressure loss characteristics of this improved surface have been determined on the test rig that was used for the development of the Calder Hall steam-raising units, and the testing and design methods are said to have been proved by the operating results at Calder Hall.

The boiler banks are to be of a forced circulation design, using centrifugal circulating pumps of the glandless type. Stand-by pump capacity is to be provided. The steam and water mixture from the boiler banks will pass to the respective



Diagrammatic arrangement of steam-raising unit

steam separator drums, which will contain rows of steam cyclones and scrubbers designed to ensure that highly pure steam is led to the superheaters and turbines, and also that steam-free water is handled by the circulating pumps. Incoming feed water from the economisers will also pass through the steam drum separating equipment, as some evaporation will take place in the economiser sections.

Feed water control will be by two-element automatic regulators, but emergency control of the feed water is to be possible from the station control room. The auxiliary equipment and mountings are designed so that all normal operations, such as chemical dosing, water sampling and blowdown, can be carried out from the bottom of the units.

The method of manufacture and construction is to be very similar to that used for Calder Hall. Ring-sections of the shells are to be fabricated, with all connections, at the Renfrew works of Babcock and Wilcox, stress-relieved at the works, and transported by sea from Glasgow to Combwich Harbour near the site. The sections are then to be welded together in a fabricating shop on the site and the circumferential welds stress-relieved by induction heating. After radiography and pressure testing, the completed shell is to be cleaned internally to a bright finish and then transported and lifted into position by the Goliath crane which is to span the entire reactor building. Cleanliness is to be maintained inside the shell throughout the installation of the banks of heating surface and other internal fittings. Warm, dry air is to circulate through them continuously during the erection operations, and all parts entering the shells are to be shot-blasted before passing through the temporary "clean-condition houses" built round the main access openings into the shells. The butt welds connecting the elements to the headers are to be made externally to the pressure shells to ensure that only those welds that have undergone the works tests are inside the gas circuit. Each element will project through and be welded to the thermal-sleeve nozzle on the shell, and this weld is to be tested under gas pressure, using sensitive detector equipment. The completed units will be boiled out or chemically cleaned on the water side before being put into service, using auxiliary steam injection into both high-pressure and low-pressure drums.

Turbo-Alternators

The six main 3000 r.p.m. hydrogen-cooled turbo-alternator sets at Hinkley Point are each to have a continuous maximum rating of 93·5MW at a generated voltage of 13·8kV and 0·85 power factor. Three 33MW variable speed turbo-alternators, of which one acts as a stand-by set, are to supply power for the gas blowers and to be of sufficient capacity to allow for possible increased output from the reactors. The main sets are to be arranged transversely across the turbine house in two banks of three, the two banks being placed on either side of the three variable speed sets. Each main turbo-alternator is to be complete as a unit with its own auxiliaries, but the whole station will have common steam and feed systems. The operating floor will be at ground level. The main turbines will be of the horizontal impulse-reaction design, with an h.p. cylinder and two l.p. cylinders, each double flow, solidly coupled in line. They will operate on the mixed pressure cycle, each l.p. cylinder exhausting to its own condenser, and will be equipped with a feed heating system consisting of drain cooler and feed heater. The hydrogen-cooled alternators are to work at a rated pressure of 15 lb per square inch gauge of hydrogen, but are designed for a maximum operating pressure of 30 lb per square inch gauge. They will have ring-type shaft seals and alternative supplies of oil to ensure safe shutdown of the sets in the event of a failure of supply. The exciter set is to be gear-driven from the alternator set. The turbines of the variable frequency sets are to be of the horizontal two-cylinder, impulse-reaction pattern, operating at variable speed. The turbine and generator rotors will be solidly coupled.

The feed heating and condensate system will be common to the whole station, and that for the variable frequency sets is to be combined with the feed heating system of the main sets. There are to be eight electrically driven feed pumps, six in operation under normal conditions, and two acting as stand-by. For emergency use there are to be two stand-by boiler feed pumps driven by d.c. motors.

Two steam dumping condensers, one normally a stand-by, are to be provided, and each is to be capable of handling 10 per cent of the total output from one reactor in the event of loss of load under emergency conditions. H.p. and l.p. steam is to be led separately to each dump condenser through dumping valves and desuperheaters. The dump condenser circulating water inlet valves will be locked in the open position. The circulating water outlet valves, which are normally to be closed, will open on the signal from the dump control valves. Interlocks are to be arranged to prevent the dump valves opening until the circulating water outlet valves are 25 per cent open, thus establishing a flow of cooling water before steam is dumped.

Control and Safety

Overall control of Hinkley Point station, vested in the station control engineer, is to be from a central room in constant communication, by telephone and light signals, with plant attendants throughout the station. The station control engineer will have authority over the two reactor control engineers.

Particular care has been taken in the design to prevent leakage from the gas circuits at such points as valves, blowers and joints. There is to be inspection by television or other remote means, to safeguard against structural deterioration of such parts as the reactor pressure vessels,

the graphite cores, the support grids, the main gas ducts and the steam-raising units. A decontamination area is to be equipped with handling and storage facilities.

The designers claim that they have taken full measures to ensure the safety of plant and personnel in the station. For example, in the unlikely event of a failure of all the gas circulators and emergency supplies simultaneously, the thermo-syphonic circulation of the gas is to be sufficient to prevent an excessive rise of temperature in the reactors. All gaseous and liquid effluents are to be monitored and filtered or treated before discharge.

Use of Non-Metallic Materials at High Temperatures

By W. J. STRANG, Ph.D., F.R.Ae.S.*

The proceedings of the sixth Anglo-American Aeronautical Conference included an unusually comprehensive review of the elements and compounds available to the aircraft builder, and particularly those which were of interest for very high performance aircraft liable to be raised to high temperatures by kinetic heating and by the power units. The speaker drew attention to derivatives of silica, including "extraordinary substances that both flow and bounce."

Structures

Plastic Structures.—It is possible to demonstrate that plastic structures are potential rivals to metallic structures for subsonic aircraft. Laminates based on woven glass fibres and epoxide resins seem to have the greatest promise.

Some idea of the potentialities of such materials at high temperatures can be obtained from Figs. 1 and 2, where specific strength and specific elastic modulus are shown for short time exposure. Average values are plotted, no account being taken of scatter which is likely to be more serious for the plastics and the titanium alloy than for the steels and the aluminium alloy. The curves for the plastics may be a little optimistic but the science is developing rapidly so that this is perhaps not inappropriate.

From these graphs it is seen that the epoxide resin laminate rapidly loses pride of place among the plastics as current supersonic speeds are approached, while the polyester resin laminates are more hopeful. It is clear that no non-metallic material is a serious contender above about 200 deg. Cent. and it is quite unlikely that they will have any primary structural application for very high speeds if more than an extremely short life is required.

Fibre-reinforced plastics may be preferred to metals for reasons other than structural efficiency. Plastic ducts are more robust than thin metal ones of the same weight and are insulating as well. Fibre-reinforced plastic pressure vessels do not shatter on failure in the way that metal ones do.

The poor conductivity of plastics and other non-metals gives rise to very high thermal gradients. Non-metallic structures, then, should be made of material with a low coefficient of expansion as well as suitable structural properties at the temperatures in question. The surface temperature will reach its equilibrium value very quickly, so that insulating structures may have to withstand higher temperatures than metallic ones in the same environment. It also follows that radiation heat losses are higher than they would be with a conducting structure, so that less heat is absorbed. This is, of course, the way an insulated structure maintains its heat balance.

There are two ways in which a material may, for a time, endure temperatures excessive to it. The more familiar of these is the exploitation of thermal inertia and heat sinks with conducting materials. In this case the temperature rise is postponed throughout the material.

The sacrificial structure operates on directly opposed principles. It is a structure made of poorly-conducting material used at a temperature high enough to cause surface deterioration. The surface quickly rises to a high temperature and is gradually consumed, but the high thermal gradient protects the lower layers. Such structures are suitable only for very short durations and are in every way extreme.

A common application of the principle is the rocket tube of a missile—an even more common application is in the more ordinary sort of firework with a cardboard and wood structure. The problem is not only one of temperature, but also of quantity of heat passing through the tube. In addition there is a severe erosion problem. Phenolic resins with asbestos reinforcements are suitable lining materials and these can be backed by glass fibre reinforced epoxide resin to give the necessary structural strength. Such a structure will last long enough for a one-shot application. Graphitic carbon is also a suitable lining material and is more resistant to erosion than the plastics. It is very resistant to thermal shock and has a high melting point, but it is much more conductive than the plastics which is a disadvantage in this application.

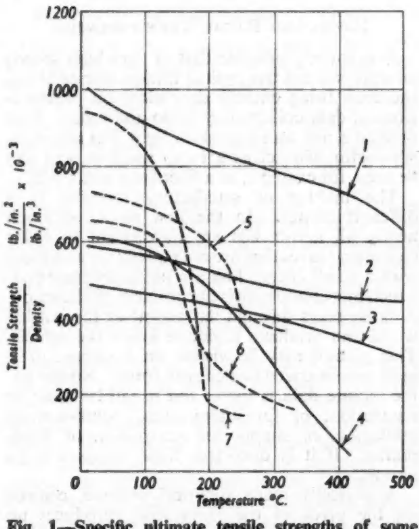
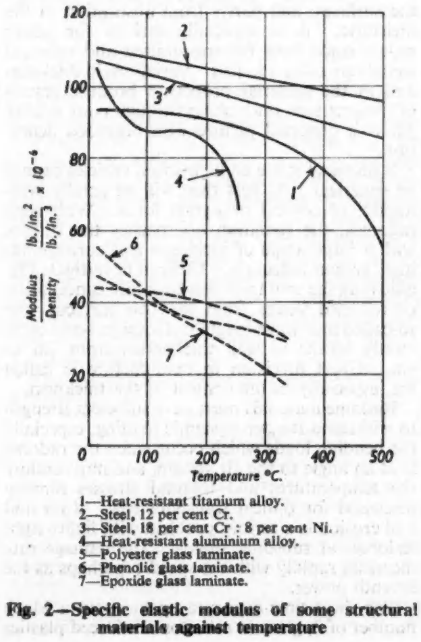


Fig. 1—Specific ultimate tensile strengths of some structural materials against temperature



1—Heat-resistant titanium alloy.
2—Steel, 12 per cent Cr.
3—Steel, 18 per cent Cr : 8 per cent Ni.
4—Heat-resistant aluminium alloy.
5—Polyester glass laminate.
6—Phenolic glass laminate.
7—Epoxide glass laminate.

Fig. 2—Specific elastic modulus of some structural materials against temperature

The sacrificial principle may also be applicable to the problem of re-entry into the earth's atmosphere; indeed it is clearly the only structural solution if speeds are contemplated which produce temperatures in excess of the highest known melting point.

Ceramics and Cermets.—As a step between the more common structural materials of to-day, with or without heat shields, and the completely sacrificial structure of the frightening future, it is pertinent to consider the use of ceramics in structures.

There seems to be some argument about the definition of a ceramic, which I am quite unfitted to resolve. There is also a vast literature on the subject with which I am ill-acquainted. My remarks are made from the point of view of the user.

Ceramics have three attractions for the aircraft designer—poor conductivity and good heat and corrosion resistance. They are mostly weak, brittle, and possessed of poor thermal shock resistance.

Some examples help to fix ideas. The following list of melting points and densities shows the range.

Table I

	Melting point, deg. Cent.	Density
Silica (about)	1600 ...	2·2
Aluminium oxide	2000 ...	3·9
Silicon carbide...	2600 ...	3·2
Zirconium Boride	3000 ...	6·1
Carbon	3500 ...	2·3
Tungsten	3400 ...	19·0

Tungsten, the metal with the highest melting point, is included for comparison. There are plenty of ceramics to rival its melting point, and they have densities roughly in the range from aluminium to steel.

The strength of ceramics is often given in terms of the modulus of rupture, i.e. the apparent stress achieved in a bending test. In quoting this the cross-sectional shape of the specimen should be defined. Modulus of rupture is a desirable figure but is of little use alone, since it is generally much larger than the ultimate tensile strength and it does not reveal notch sensitivity.

The tensile strength of the stronger ceramics is usually in the 10,000 lb to 20,000 lb per square inch range, but I find a report of silicon carbide achieving a modulus of rupture of 70,000 lb per square inch at 1400 deg. Cent. Ceramics are usually several times as strong in compression as they are in tension, and in some cases the rather low tension strength is severely reduced at high temperatures. The thermal conductivity of ceramics is usually low, but for some of the more conductive ceramics the figures are comparable with those of stainless steel.

Cermets use a metallic bond for the refractory particles. The composition varies, some recipes containing only enough metal to give a very thin film and some being solid solutions. In some cases there is a degree of chemical interaction. These materials generally sacrifice resistance to heat in exchange for resistance to thermal shock. They are naturally more acceptable to an aircraft designer, if he should have any degree of conservatism in his make-up.

Ceramics have traditional applications in the electrical industry. As structural materials the applications which first suggest themselves are in the propulsion field—turbines and their stators, and nozzles. The strength required is not excessive, perhaps 10,000 lb per square inch at typical ceramic material densities, and there are materials which provide it and show superiority to the current nickel- and cobalt-based alloys on a simple strength/density basis at high enough temperatures. Brittleness and poor thermal shock resistance have so far prevented the exploitation of this promise—an altogether unsurprising state of affairs.

Ceramic nozzle liners have been successfully employed and indicate a more likely line of development in the use of these materials. A great deal of progress has been made in devising

* Bristol Aircraft, Ltd.

methods of applying protective ceramic coatings to metal structures. In this way the engineering virtues of metals are allied to the corrosion and erosion resistance of high temperature ceramic surfaces. There are several techniques. One device is to spray a molten cermet on the metallic surface, and the bond may be assisted by chemical interaction with the metal itself. It is also possible to produce the ceramic coating *in situ* after metal spraying with, for example, aluminium.

These techniques of using ceramic coatings appear very attractive, and will no doubt develop largely. Perhaps the greatest contribution ceramics could make to gas-turbine technology is to provide a protective cover for such metals as molybdenum and niobium.

Ceramic airframes, except in the way of radomes, appear to me wholly unlikely. But ceramic or cermetallic insulating layers for metallic structures will be essential if we insist on very high Mach numbers at high indicated air speeds.

Thermal Insulation

The notion of the sacrificial structure leads naturally to the idea of external insulation of metal structures. Both arrangements postpone the attainment of high temperature in the interior, without altering in any way the temperature that would be attained with a prolonged heat soak. The time-scale depends on the insulation thickness and on the size of the heat sink, as well as the speed and altitude, so it is difficult to summarise.

One of the great difficulties with external insulation is the securing of a bond between the insulation and the underlying structure, and there is a conflict in requirements. For thermal shock resistance of the ceramic cover itself, the lowest possible coefficient of expansion is required, but stability of the bond under temperature cycling requires compatibility of thermal expansion between the insulation and the underlying metal. It may be possible to compromise with cermetallic covers whose properties are suitably graded through the thickness. Some practical use has already been made of such arrangements, but only in the very minute thickness appropriate to corrosion-protective layers.

Thermal insulation is also necessary for various internal parts of the aircraft. If a pilot is carried then he must be protected from conducted heat through the structure and the controls. He must also be provided with air at a reasonably comfortable temperature and humidity. This entails a pressurised cabin and some of the more sensitive equipment might be put in it, but there will still be a need for thermal insulation of many components mounted elsewhere in regions where it will be difficult to avoid some ventilation. For example, consider a hydraulic pump unit weighing 40 lb in an aircraft which is taken up rapidly to 35,000ft and flown at a Mach number of 2½. If there is some leak of boundary layer air flowing over it at 10ft per second then it would heat up initially at 2½ deg. Cent. per second, but if a 1in thick glass blanket insulation weighing 2 lb is used then the rate would be reduced to 1 deg. Cent. per second.

Electrical Insulation

For flexible cables silicone rubbers are suitable up to the 150 deg. to 200 deg. Cent. range, above which the more expensive P.T.F.E. materials might extend the range to about 250 deg. Cent. Both the silicone rubbers and P.T.F.E. have a low temperature limit of about −75 deg. Cent. P.T.F.E. has a tendency to flow at the upper end of the useful range and glass fibre reinforcement is necessary.

For higher temperatures mineral insulators can be used with an external metallic sheath for protection against damage and for the exclusion of oil and moisture. Rather complicated designs of connections are necessary to ensure sealing. Such cables are not very flexible and if this property is needed it is necessary to consider discrete solid insulators on a "string-of-beads" principle. Clearly, this brings back the problem of the exclusion of fluids and moisture.

Solid insulators for high temperatures have been made for many years; they occur, for example, in engine sparking plugs. Ceramics and glass are obvious choices but they are heavy. For short time exposure some nylon polymers could be considered for applications up to 200 deg. Cent.

Optical Transparencies

The design of transparencies for high-speed aircraft is a difficult and interesting problem. The chosen materials, in addition to being transparent, must withstand (*a*) pressure loads arising from cabin pressurisation, (*b*) pressure loads arising from the external aerodynamics, (*c*) aerodynamic heating and perhaps heat from demisting arrangements, and (*d*) impact and erosion, especially from rain and hail.

The available materials are the transparent plastics, glass and silica. The plastics, which are rather easily scratched and abraded, are commonly used as an interlayer between glass sheets, and also, of course, for double-curved canopies. They have good thermal shock resistance, but are not of much use above about 150 deg. Cent. Glass is vulnerable to thermal shock, but is readily available in sheets of good optical quality. The material of the future is undoubtedly silica, which has a coefficient of thermal expansion sixteen times smaller than that of glass.

The difficulties with glass can be alleviated by more complicated designs, using double panels in which the outer acts as a heat shield. Even so, the use of glass above a Mach number of 2 is definitely risky. Only silica is really suitable for higher speeds. It will have a practical temperature limit somewhere below the melting point of about 1600 deg. Cent.

Radio and Radar Transparencies

It is entirely possible that at very high speeds aircraft will not use optical transparencies at all, the crew being entirely dependent on presentations of data collected by radio and radar. Few materials are transparent to light, but any non-conductor will act as a radio window, and can be used, for example, as a filler for a slot aerial.

The making of satisfactory radomes is a different matter. In the first place, although nearly all non-metals are transparent to radar frequency waves they are not equally so, and those with a small energy loss are naturally preferred. Much more important is the problem of distortion. A radar peers through its radome at the outside world and produces a picture inside the vehicle. This picture may be visible on a screen, or it may remain coded in electrical form. No matter, the picture data is there, and it will be used for navigation, or for interception, bomb-aiming, gunlaying, or simply for recognition of landmarks. If it is distorted, these things will go wrong.

A perfectly made spherical radome, centred on the pivot of the radar dish, produces no distortion, although it does cause an electrical loss. This loss arises partly from reflections at the surfaces, and partly from absorption in the dielectric. It is especially serious for active radars since both the transmitted and reflected signals are subject to loss. Variations in thickness and in the material properties produce results of the sort seen on looking through poor quality glass—a distorted picture with degraded definition.

Radomes for use on high-speed vehicles cannot be spherical. At best they will be axially symmetric, of conical or ogival form. With such radomes, the radiation approaches the surface with a large angle of incidence and correspondingly greater reflection. This can be mitigated by adjusting the wall thickness to secure cancellation of reflected waves from the two surfaces—the so-called half-wave-length wall design—and commonly results in wall thicknesses from ¼in to ½in. Great precision in manufacture is called for, especially in the control of the thickness.

Radome materials must have sufficient strength to withstand the aerodynamic loading, especially the bending loads which occur when the radome is at an angle to the air stream, and must endure the temperatures and thermal stresses already discussed for optical transparencies. Rain and hail erosion is a serious problem with lightweight radomes at subsonic speeds. The damage rate increases rapidly with the speed; perhaps as the seventh power.

For short time exposure up to about a Mach number of 2, glass or asbestos-reinforced plastics can be used. For higher speeds and for long-term rain exposure at any supersonic speed, the only suitable materials appear to be ceramics, silica and silica-glass. Solid wall radomes of these materials are quite practical, but are heavy, and efforts are being made to produce ceramic radomes of sandwich construction. The principal difficulties are variations in the electrical properties of the foamed core and poor adhesion between the core and the skins after thermal cycling.

Fuels

Leaving aside atomic fuels, the choice of fuels for air-breathing engines includes hydrocarbons, hydrogen and possible high-energy fuels based on boron. Table II gives calorific values:

Table II

Fuel:	B.Th.U./lb	B.Th.U./cu. ft.
Liquid hydrogen ...	52,000	309,000
Hydrocarbon ...	20,000	1,000,000
Boron based, up to ...	32,000	1,170,000

The superiority of the boron-based fuels is clearly shown—about 40 per cent better than hydrocarbons on a space and weight basis. Like most unorthodox fuels, these bring a string of problems. Some of the compounds can cause such erosion after combustion that they can be used only in afterburners or ram-jets. Most are difficult to handle in some way or another and many have an inconvenient tendency to decompose or blow up. The difficulties are unlikely to be insurmountable for special applications, but it seems that it is not without reason that hydrocarbons are almost the universal fuels.

Liquid hydrogen is the supreme fuel on a weight basis, but has such a low density that it is much inferior to hydrocarbons where space is a ruling consideration. It presents extremely severe handling problems; it cannot remain liquid above 33 deg. K., at which temperature it requires thirteen atmospheres of pressure, while at atmospheric pressure it boils at 20 deg. K. When freshly liquefied it is mostly ortho hydrogen but slowly changes to nearly all para hydrogen with a rate of heat release greater than the latent heat in the ortho form. Unless this heat is removed it will evaporate some of the remaining ortho hydrogen and about half the liquid will be lost. By using a refrigeration system based on helium, which has a lower boiling point than hydrogen, these difficulties can be largely overcome and the liquefaction can be done at low pressure.

In spite of all difficulties the very low weight will always be attractive and the low temperature may appeal to the designer as a heat sink for a very fast aircraft. One can visualise an arrangement in which the liquid is kept cool by refrigeration until take-off and is then used at the same rate as it evaporates while simultaneously cooling the structure. Fearsome differential temperatures are implied.

There are other difficulties of course. When mixed with air the explosion limits are very wide and it achieves spontaneous combustion at about 250 deg. Cent.

Lubricants

The basis of lubrication is the prevention of cold welding at high spots. Considering liquid lubricants, the common mineral oils are useful up to about 100 deg. Cent., the synthetic ester lubricants can reach about 150 deg. Cent., and the silicone oils and greases up to about 200 deg. Cent. These higher temperatures are not reached without some disadvantages. It seems reasonable to hope for liquid lubricants for temperatures up to about 300 deg. Cent. or more.

For very high temperatures much attention has been given to molybdenum disulphide. This can be used as a surface treatment for some steels and gives good results at high bearing pressures, once the metal pre-treatment and lubricant application are well developed. Temperatures up to about 600 deg. Cent. are reasonably expected—the ultimate limit would be 1000 deg. Cent. when chemical deterioration sets in.

Some materials are suitable as solid lubricants, or, more strictly, bearing materials that require no lubrication. Graphite is a common bearing material suitable for quite high temperatures, and for low pressures P.T.F.E. can be used. This material has a chemical stability limit of 327 deg.

Cent. but poisonous vapours are given off before this temperature is reached.

Fuel Tanks

Because the fuel is a good heat sink there is no difficulty in keeping the submerged part of the tank cool, but the portion out of the fuel will quickly heat up unless fuel is sprayed over it. Bag tanks are wasteful of space and weight, but they may be essential for very high speeds or long duration.

Integral tanks are more economical in space and they cool the structure, which in turn implies that the fuel they contain heats up more quickly than fuel contained in bags. The cooling of the structure, if it occurs locally, is a nuisance and gives rise to unwanted thermal stresses. In other designs the cooling of structure by fuel may be a fundamental feature of the design. At all events, a need for tank sealants exists and will persist.

The limit for organic sealants, e.g. thiakol rubbers, is about 150 deg. Cent., or perhaps 200 deg. Cent. for very short periods. Silicone rubbers mixed with epoxy resin will go higher, perhaps 250 deg. Cent., but they tend to swell in contact with fuel. The use of fluorinated silicones may overcome this, and no doubt many other developments will be forthcoming. They are badly needed.

The insulated type of structure, with internal fuel sprays, does not present any particular sealant difficulty as long as full trust is put in the sprays. The whole design concept brings it within the scope of existing sealants.

Hydraulic and Pneumatic Pressure Seals

The position is rather similar to that of the tank sealants. Organic rubbers can be used to about 200 deg. Cent., silicone rubber to perhaps 250 deg. Cent., but only at low pressures (below 1000 lb per square inch) to avoid extrusion. Stainless steel gas-filled rings are another possibility, applicable to much higher temperatures, as are carbon or metallic piston rings.

Adhesives

The ordinary adhesives for metals are not trustworthy for temperatures much in excess of 100 deg. Cent. Modifications to the standard treatments give improved hot strength, and by using phenolic resin alone a low strength bond can be obtained up to 250 deg. Cent. It is quite possible to produce a bond between steel or aluminium and asbestos or glass-reinforced phenolic resin by curing the resin in contact with the metal, after suitable pre-treatment, and this is one of the hopeful ways of making an insulated structure suitable for temperatures up to about 250 deg. Cent. There are other adhesives which are suitable for similar temperatures and considerable development is likely.

A possible way to bond ceramics to metals is to plate them first—in fact, a sufficient thickness of plating can be used as the underlying structure. There is one hopeful feature of this insulation bonding problem—the very use of an external insulator implies that the bond temperature cannot be very high.

Tyres

The weight and volume of the landing gear is grudged by every aircraft designer, and the tyres of high-performance aircraft are invariably loaded near their limits. During the take-off ground roll the tyre temperature rises due to friction of the deformed tyre with the runway and due to mechanical hysteresis in the tyre material. The temperature rise may be reduced by increasing the inflation pressure, which minimises the tyre flexing and, of course, by fitting bigger tyres. In any case, the problem is a familiar one, to be dealt with in the usual way.

It does, however, mean that the tyres are already hot when retracted into their stowage well, so there is little to be hoped for from thermal inertia. The wheel well temperatures during the course of the flight are particularly difficult to control, because of the very real difficulty of ensuring freedom from leaks of the hot ambient air. For this reason, refrigeration of the wheel wells is liable to be very expensive in cooling demand, and it is fortunate that a tyre at rest can be allowed to attain a somewhat higher temperature than would be permissible under its duty load.

Finally, the tyre is required for landing, and the temperature will rise again during the ground roll. The operation of wheel brakes increases the temperature still further. This makes it necessary to cool the tyres well below their limiting temperature before touch-down. A simple method is to expose them to the air stream at a moderate speed for some time before touch-down, and it may be worth while providing for ventilation of the wheel well during subsonic flight.

The maximum allowable wheel well temperature with currently available tyres is about 130 deg. Cent., and the allowable touch-down temperature is about 90 deg. Cent. These temperatures are severely limiting.

The problem of raising these limits is a severe one since so many of the requirements are apparently in conflict. An elastomer is required that is strong and resilient at high temperature, but it must also be satisfactory at very low temperature since that can be the condition at the start of a take-off. At all temperatures resistance to abrasion is essential. For a given material there is some scope available to the tyre designer to change the characteristics by varying the shape and cross section of the tyre, and on his ingenuity and experiment will depend the finding of the best compromise. One would expect the carcase to be a simpler problem since steel wires can eventually be used if a sufficiently good elastomer is developed.

Wheel Brakes

Brake pads, until recently, have been generally non-metallic but cermets are now coming into use having certain advantages.

With a perfect brake the wheel torque would build up to a value that would remain constant throughout the rest of the stopping operation. In practice, the torque varies considerably during stopping.

After the initial peak the torque falls off due to heating, this effect being overtaken later in the operation by an increase due to reduced rubbing speed. The maximum torque is a stressing case and hence the excess of the maximum over the mean represents a weight penalty. In a typically good design the maximum/mean ratio would be about 1·3.

Non-metallic brake pads are poor conductors and hence nearly all the heat produced must soak into the metal brake discs. This decides the weight of the discs. With cermetallic pads much more of the heat can be taken into the pads, or through them to the supporting structure, and in this way an overall weight saving can be made.

The art is to have a sufficiently metallic cermet to absorb and conduct the maximum of heat without running the risk of welding the pads to the discs in normal operation.

National Anti-Corrosion Week

During the week October 14 to 19, 1957, there will take place a Corrosion Convention at the Central Hall, Westminster, and a Corrosion Exhibition at the Old Hall of the Royal Horticultural Society. The exhibition is open on October 15, 16 and 17, the latter two days coinciding with the London Regional Display of the Engineering Industries Association in the New Hall. All stand space at the exhibition has already been taken up, but complimentary admission tickets are obtainable from the Organiser, Stratford House, 9, Eden Street, London, N.W.1.

The programme for the convention is as follows :—

Tuesday, October 15

9.15 a.m. to 10 a.m.: "Corrosion in the Oil and Chemical Industries," by H. B. Footner, Ph.D., B.Sc., F.R.I.C., Shell Petroleum Company, Ltd.

10 a.m. to 10.45 a.m.: "Corrosion in the Shipping Industry," by S. R. Bew, M.I.N.A., Niarchos (London), Ltd.

11 a.m. to 11.45 a.m.: "Packaging to Prevent Corrosion in Transit and Storage," by F. A. Paine, B.Sc., A.R.I.C., and D. Watkinson, B.Sc., Printing, Packaging and Allied Trades Research Association.

2.15 p.m. to 3 p.m.: "Corrosion and Water Treatment," by G. G. Sindery, A.M.I.Mech.E., Houseman and Thompson, Ltd.

3 p.m. to 3.45 p.m.: "Protective Pipeline Coatings in the Public Utilities," by W. D. Parker, B.Sc., F.R.I.C., and A. G. Wilkie, A.R.I.C., Winn and Coales, Ltd.

4.5 p.m. to 4.50 p.m.: "Fuel Additives in the Fight Against Corrosion," by B. J. Zaczek, Ph.D., D.I.C., A.M.I.Mech.E., and R. Grindley, Ph.D., M.Sc., The Amber Chemical Company, Ltd.

7.30 p.m.: Official convention dinner, to be held at the Waldorf Hotel, Aldwych, W.C.2.

Wednesday, October 16

9.30 a.m. to 10.15 a.m.: "Paints and their part in the Fight Against Corrosion," by H. Hollis, B.Sc., A.R.I.C., and L. J. Coleman, Ministry of Supply Chemical Inspectorate.

10.15 a.m. to 11 a.m.: "Corrosion-Resistant Metals and Alloys," by J. B. Cotton, A.R.I.C., head of corrosion research, I.C.I. Metals Division.

11.20 a.m. to 12.10 p.m.—"Vinyl Resins in the Construction of Chemical Plant," by W. E. Martin, B.Sc., BX Plastics, Ltd.

2.15 p.m. to 3 p.m.—"Cathodic Protection," by W. Godfrey Waite, director, F. A. Hughes and Co., Ltd.

3 p.m. to 3.45 p.m.: "Sprayed Metals and Plastic Coatings," by G. H. Jenner, B.Sc., Schori Division, F. W. Berk and Co., Ltd.

4.5 p.m. to 4.50 p.m.: "Hot Dip Galvanising," by W. L. Hall, General Galvanisers, Ltd.

Application for registration among the delegates may be made to the Convention Organiser, *Corrosion Technology*, Stratford House, 9, Eden Street, London, N.W.1.

18kW H.F. Induction Heater

An 18kW high-frequency induction heater designed to occupy less than 11 square feet of floor space and provide enough power for surface hardening and for brazing heavy sections, has been introduced by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. It has a power output control which adjusts the impedance matching of the load by varying the coupling between the tank coil and the concentrator to which the heating coils are attached. Other controls are a main switch, a remote control unit with stop and start push buttons and an automatic resetting process timer and switch.

Normally a single work station is provided, but the equipment can be arranged for two work stations. The work coils are easy to make and to interchange, as they are readily detachable from the generator and water connections are incorporated. Cooling is provided by a filtered air blast to the oscillator valve and interior of the set. A small amount of ordinary mains water is required for cooling the output transformer and heating coil ; a water-flow switch shuts down the set unless sufficient water is flowing.

Power input is about 36kW, we learn, with 18kW power output. The valves used are a BR.1102 oscillator valve and six G.E.C. GU.21 mercury vapour rectifier valves for full wave rectification of supply to the oscillator valve. The frequency is about 500 kc/s. An anode current meter indicates the output power and an hour meter records valve life. A green signal light indicates "Mains on" and a red light glows when the set is in full operation.

Interlocks are provided on all panels and doors to prevent the h.f. contactor being closed inadvertently. Filters are fitted in the supply leads to prevent unwanted h.f. currents being fed back into the mains supply.

The front panels of the set are stove-enamelled polychromatic silver. The supports for a work table, which are fitted on the lower front panel, and the output control guide plate are chromium-plated. The remainder of the unit is stove-enamelled Oxford blue. Retracting trunnions are provided at the base.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

FAIRGROUND TUNNEL RAILWAYS

SIR,—I have read with the greatest interest the articles by Mr. R. A. S. Abbott in your issues of August 9 and 16, in which known examples of tunnel railways are described in commendable detail, and some interesting and hitherto unpublished data brought to light. I beg to offer, however, a little additional information, and one or two minor corrections.

With regard to the example which lay disused in Berkshire until recently, it may be of interest to note that in its final form this outfit had a "semi-raised" track. The rails were no longer at ground level (as in Fig. 10), nor were they raised to the height of a road wagon (as exemplified by the drawing, Fig. 3). When the track was assembled, the four road wheels were removed from the truck, whose axles then rested on low blocks on the ground. I estimated the track elevation of this machine to have been about 2ft. Incidentally, the road truck was, in this instance, long enough to carry one carriage, as well as the locomotive.

These remarks are based on my personal observation of the outfit built up in the Maxwell Playing Felds at Beaconsfield on August 3, 1944, at a wartime substitute for that town's chartered (street) May Fair. Mr. Abbott has apparently been misinformed with regard to the non-materialisation of the wartime project to recommission this machine. Early in 1944 it was purchased from Messrs. Woolls by a showman who was at the time engaged in renovating old machines to meet the minor boom which fairs were then enjoying. After effecting repairs, he erected it for the inspection of prospective purchasers in the "Swan and Bottle" Meadow at Uxbridge, where I saw it on April 8, 1944; but as far as I know rides on it were not offered to the public there. The outfit was purchased by one of the Beach family, then of Maidenhead, and, rechristened "The Victory Express," it operated at several fairs in 1944, including, to my knowledge, Windsor in May, Cookham in June, Beaconsfield in August (where I saw it), and later in that month at Marlow, after which it disappeared. I feel confident that these were the last public appearances of any steam tunnel railway in this country, and they occurred something like ten years after the disappearance of M. Jervis's set from the Lickey Hills amusement park. Messrs. Beach used a Foster 5-ton "Wellington" type compound steam tractor (works No. 14088) for hauling the tunnel railway from fair to fair.

Another correction I would offer concerns the spelling of the names of two showmen who are mentioned in the articles. The second owner of Savage No. 643 was M. Jervis (pages 192 and 222) and the original owners of "Champion" were Messrs. Hancock (page 221).

I have reason to believe that the steam tunnel railway enjoyed a measure of continued popularity on the Continent. A set was reliably reported to be in operation at the Paris (Place d'Italie) Christmas and New Year Fair as recently as 1951–1952. This could have been Savage No. 645, or possibly one of the T. Green sets which went to Germany originally, or, most probably, a "locally built" example. Since then, I have heard no report of any set in operation anywhere.

Finally, in view of the recent revival of interest in the Channel Tunnel project, one wonders whether there will be a corresponding revival of the fairground tunnel railway, built according to modern engineering practice. If so, it will probably be necessary to fold back the canvas "tunnel" at intervals, to allow dispersal of diesel fumes, just as was done sixty years ago, I am told, when the expressions on the faces of emerging passengers indicated that the build-up of coke fumes in the tunnel was getting beyond a joke.

P. W. BRADLEY

Epsom,
Surrey,
September 12, 1957.

Book Reviews

Britten's Old Clocks and Watches and Their Makers. Revised by G. H. BAILLIE, C. CLUTTON and C. A. ILBERT. E. and F. N. Spon, 15, Bedford Street, London, W.C.2. Price 147s.

THIS is a completely revised version of the late F. J. Britten's volume, which, originally published in 1899, had for many years been widely accepted as a standard work on horological history and had appeared in six editions, the last of which was issued in 1933. When the need for a seventh edition became apparent it was decided that, in order to embody the large amount of additional information that had become available, an extensive revision was necessary. The new edition departs from the general form adopted by the original author to an extent which makes it almost a new work.

The first chapter of the seventh edition is entitled "Counting the Hours" and deals with the earliest methods of time measurement, giving, in condensed form, some of the contents of the first three chapters of the previous editions. A regrettable feature of this compression is that very little is said about the fine examples of mediæval clocks still in existence in this country and on the Continent. Former editions dealt with these at some length, and although the descriptions contained errors and dated some of the clocks incorrectly, they did, at least, embody the best information then available. In recent years much has been discovered concerning both the mechanism and the history of such clocks as the Wells, Exeter, Rouen and Strasbourg timekeepers, and other important new examples have come to light. In addition, excellent illustrations of all these clocks and their mechanisms are available. This being so, it does seem unfortunate that the opportunity has, to some extent, been missed to correct former inaccuracies and to illustrate and describe in detail some of the oldest machines still remaining in the world. Again, no mention seems to be made of the complicated astronomical and planetarium clocks constructed by early makers.

The development of domestic clocks and of watches is given much space in the following chapters. Much, too, is made of what is described as "The Age of Decoration." It certainly seems that the makers of those days devoted as much, or even more, effort to embellishing their productions than to the mechanical details, so the accent given to this aspect, though it may at first appear a little disproportionate, does reflect the trend of the time. All movements were then fitted with verge escapements, and the great strides towards precision of timekeeping had yet to be made.

The rapidity with which most of the improvements appeared when they did eventually come is stressed very clearly when the matter of "Counting the Minutes" is dealt with. As the chapter truly says, "In 1655 a clock did well to keep time within five minutes a day; in 1675 its error might, under favourable circumstances, be only a matter of as many seconds." That this was so was due to the work of a number of brilliant men who, between them, introduced the pendulum and the balance and spring, and contrived the escapements that enabled the proper use to be made of the isochronal properties of these two devices. The story might well have been told in more detail than the eleven-page chapter to which it is limited in this book, though, in justice to the revisers, it must be said that it is continued in the next part of the book, which deals with the supremacy of English horologists and makers in what has rightly been called the "Golden Age" of horological development. Whilst the main inventions of English makers are all included in this chapter, the greater part of the space is devoted to descriptions of case and dial styles and to what might be called the "collector's" angle.

The account of the improvements to timekeepers which enabled them to perform with an accuracy previously undreamed of is one of the best parts of the whole book. It centres, and probably quite rightly, on watches and marine chronometers, the latter being dealt with in a special sub-section entitled "The Longitude Story." Even so, it must not be thought that clocks are ignored, for some outstandingly fine examples of the kind of timepiece known as a "regulator" are included and well illustrated.

Most of the watches shown are superb examples, and there is a very full and well-illustrated description of the first lever watch ever made. This was constructed by Thomas Mudge, the inventor of the lever escapement, for King George III, and given by him to Queen Charlotte, and, apart from its historic importance, it is outstanding as being the forerunner of all the millions of lever watches and escapements in use to-day. A description of the construction and action of a modern lever escapement included enables the essential points to be clearly grasped.

Two chapters deal in turn with French clocks, which merit such treatment by reason of their strongly individual style, both in mechanism and case design, and other national styles, which, though perhaps less pronounced than those of France, still call for mention. The one point that seemed to call for query in the chapter on French clocks was the attribution of the pin-wheel

escapement to Amant, for this very useful form of dead-beat escapement has also been claimed for John Whitehurst, a Derby maker.

Technical details of alarm, striking and repeating mechanisms, accompanied by good drawings, explain the actions of these parts of a clock very well. A preliminary to the tremendous list of former makers which has always been a feature of this work, is a chapter which deals with the histories of the more famous makers in chronological order instead of giving them alphabetically in their place in the longer list.

In the appendices a good glossary of technical terms might have been improved if it had been illustrated with some simple diagrams of the parts or mechanisms described. Hallmarks and date letters, the latter from 1678 to 1835, form the second appendix, and a fairly complete bibliography the third. The whole of the rest of the volume, comprising nearly 200 pages, is occupied by an alphabetical list of former makers accompanied by any items of interest available.

A noteworthy feature of the whole work is the high quality of its illustrations, which are uniformly clear and distinct. The line drawings are clear and there is an excellent folding frontispiece, which reproduces a semi-technical, semi-pictorial drawing of a fine Tompion bracket clock.

Although the book is not the familiar "Britten" of the earlier editions, it is a welcome addition to horological literature.

Switchgear Principles. By P. H. G. CRANE. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 25s.

IN the preface this book is stated to be intended for the use of students, and that an endeavour has been made to give basic facts on the subject of switchgear design principles. The main essentials of a book with such objects should surely be clarity of presentation and adherence to proved and up-to-date information. It is very unfortunate, therefore, that many of the statements in the book are so generalised as to become sometimes actually misleading, and in many cases inadequate distinction is drawn between theories which have been established and those which are mainly matters for speculation. The book contains such misleading statements as: "it is unlikely that busbar currents of 2000A, or voltages of 275kV will ever be greatly exceeded." Systems having values considerably exceeding these figures are already in operation. To show 3·3kV as a typical distribution voltage is out of accord with modern system planning, and unqualified statements such as: "if the fault exists only for a period of about one second or less, there may be no justification for opening the circuit normally and thus interrupting supplies," are irritating to those with practical experience. Throughout the book statements are made regarding over-voltages without any clear distinctions being drawn between those which are normal and harmless and those which are dangerous to the system insulation; and the few sentences given to "protection against over-voltage effects" can hardly be regarded as adequate and are in some respects misleading. Fuses are disposed of in six short paragraphs, a typically confusing statement being: "There is also a tendency for cut-off to produce over-voltages in reactive components of a circuit and, although h.v. fuses have been manufactured, their use is mainly confined to low-voltage systems."

Except for about fifty pages the whole book is devoted to circuit breakers. Much of the chapter on electrical discharges is of a very speculative nature, interesting but of little help to the student of circuit breaker design, while the chapter on principles of circuit breaking provides a confused picture owing to the lack of co-ordination between the principles mentioned and actual practical circuit breaker designs for different voltage ratings. In the chapter on oil circuit breakers almost all the statements are of a very general kind, without any practical data to support them, thus leaving the reader without any real guidance as to what is, in fact, good practice. Many of the items mentioned are associated with designs which have been out of date for many years, and the illustrations are poor, and do not cover a sufficiently wide range of modern designs. Air-break circuit breakers are dismissed in four paragraphs and illustrated by a design which has been obsolete for nearly twenty years. Air-blast circuit breakers receive rather more attention, but the treatment is so elementary that the reader gains no picture of the range of modern designs which is available. The chapter on tests and specifications is based on relevant British Standards but the interpretations of them do little to assist the reader to understand them.

At the end of the book is given a list of references upon which the book has been based. Most of these are by authors well-known in the switchgear industry.

Metrology and Gauging. By S. A. J. PARSONS. Macdonald and Evans, Ltd., 8, John Street, Bedford Row, London, W.C.1. Price 25s.

THIS is a book which will be welcomed by students and teachers of metrology, for there are still few good textbooks on the subject. It should also prove a useful reference book for those who are concerned with metrological measurements in the engineering industry. Mr. Parsons has read widely in his subject and a valuable feature of his book is the very extensive, up-to-date list of references. The book is a comprehensive introduction to a wide range of topics beginning with the fundamental standards and dealing in turn with interchangeability; design, manufacture and use of gauges; principles, design and use of measuring instruments; measurement of screws and gears; measurement of surface texture. A penultimate chapter on the basic ideas of straightness, flatness and alignment might with advantage have come earlier. Appendices giving a selected list of relevant British Standards and typical examination questions on metrology will be found useful.

The discussion is usually clear and unambiguous, but the chapter on pneumatic measuring devices is one which Mr. Parsons will want to re-write when more literature becomes available on this technique. The book is refreshingly free from mistakes, but there is a numerical error on page 235 where the magnification stated as $\times 1600$ should be $\times 16{,}000$.

Books Received

British Chemicals and Their Manufacturers 1957. The Association of British Chemical Manufacturers, Cecil Chambers, 86, Strand, London, W.C.2. Issued free.

How to Become a Successful Manager. By Harold Whitehead. George Allen and Unwin, Ltd., Ruskin House, 40, Museum Street, London, W.C.1. Price 15s.

Reinforced Concrete Designers Handbook. Fifth Edition. By Charles E. Reynolds. Concrete Publications, Ltd., 14, Dartmouth Street, London, S.W.1. Price 18s.

Technical Reports

Der Einfluss der physicalischen Eigenschaften von Mineralölen auf deren Mischbarkeit mit dem Kältemittel Frigen 22 (CHF_2ce). By Dr.-Ing. Hans-Jürgen Löffler. Abhandlungen des Deutschen Kältetechnischen Vereins, No. 12. Verlag C. F. Müller, Karlsruhe: Price DM.7.50.—The present investigation which was carried out at Karlsruhe Technical University, was concerned with certain physical characteristics of Difluormonochloromethane (CHF_2ce), known commercially as Freon 22 or Frigen 22. This liquid which is taking the place of Difluordichloromethane (CF_2ce_2)—known as Freon 12 or Frigen 12—for temperatures below −30 deg. Cent., is only partially miscible with the mineral oils used, and tends to precipitate paraffins.

The low miscibility leads to difficulties in the evaporator, since the oil cannot absorb enough Freon 22 to render it sufficiently fluid. Paraffins separated out tend to block expansion valves and other parts. Separation during standstill may cause breakdown in the lubrication of bearings and pistons due to oil-weak mixtures from the bottom of the sump getting into the pump. Although the danger can be reduced by design changes, the problem can be considerably simplified by a suitable selection of the oil. Data in the literature are, however, of little help because the detailed information is not available. The present work investigates the relation between miscibility and oil composition. (The question of paraffin segregation is to be dealt with in a subsequent paper.) A general equation is developed on the basis of energy and statistical considerations, giving the solubility of mineral oils in Freon 22. The constants in this equation are derived from mean values of the parameters giving the molecular composition of the oil. The method, it is stated, achieves an accuracy of 2 to 3 per cent, sufficient for practical use.

L'année Ferroviaire 1957. By R. Dugas, P. Mayeux, P. Dubost, E. Bidet and G. Serrell. Librairie Plon, 8, rue Garanciére, Paris (6e). Price: Fr. 795.—This is the eleventh edition of an annual which first appeared in 1947. From the wealth of information on the French Railways which this volume contains, only a few can be selected here for special mention. Technical progress and productivity increases have been characteristic for the post-war development of the S.N.C.F., and in this connection the reader will appreciate the detailed account of the third five-year plan for the period 1957–61. Another article of interest, particularly to the layman, is the description of the production of a railway timetable. The third chapter brings an account of the role of the railway in the framework of the Common Market for Iron and Steel. Door-to-door traffic by means of road-rail containers is the subject of Chapter IV, which includes the story of the extension of mechanical handling facilities. The importance of public opinion and market research is brought out in another article, where examples are quoted of how the information obtained in polls can be of use to industry. In the second part of the annual are found the customary eight chapters on world railway statistics and technical matters, on the French Railways (personnel, financial, traffic, engines, rolling stock, fixed installations and shipping).

Industrieofenbau. By J. H. Brunklaus. Vulkan-Verlag Dr. W. Classen, Haus der Technik, Hollestrasse 1g, Essen, German Federal Republic. Price DM. 46.—While the number of factories using ovens or furnaces for some part of their process is constantly increasing, there existed until now no book which dealt with this field in a general manner, including in its scope not only the furnaces of the metal industries but also furnaces and ovens for other purposes. The present book deals with all aspects of construction and operation, such as the varieties of basic designs, materials, roof calculations, combustion, determination of combustion chamber space, heat balance, thermal efficiency, warming-up and idling, heat losses and heat storage, recuperation, burners and burner calculations, heat transfer, heat flow, oven calculations, and many other topics. Certain special problems, such as combustion under pressure and internal recuperation, are dealt with separately in an appendix.

Brennhärten und Ortliche Wärmebehandlung. Tabellenbuch für die Benutzer des Peddinghaus-Verfahrens. By Dr.-Ing. H. W. Grönegress. Vulkan-Verlag Dr. W. Classen, Haus der Technik, Hollestrasse, 1g, Essen, German Federal Republic. Price DM.9.60.—The object of the present handbook on flame-hardening is to collect the widely scattered material in this field and to arrange it so as to make it convenient for daily use. It comprises articles on the various aspects of flame-hardening, quenching and other technical aspects, soldering and heat-treatment, as well as a list of patents, and sections on nomenclature and important German standards. There is a large number of tables which occupy the second part of the book.

Engineering and Marine Exhibition

No. IV—(*Concluded from page 389, September 13*)

The twenty-first Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia, London, ended on Thursday of last week. During the fortnight of the exhibition, there were visitors from no less than sixty-eight overseas countries, visitors from the Netherlands, Germany, Italy and India being particularly numerous. During a final tour of the stands, many exhibitors commented on the interest shown in their products. In our last three issues we have described a great deal of the machinery and equipment displayed at Olympia. Our account is concluded on this and following pages.

Metropolitan-Vickers Electrical Company, Ltd.

A NUMBER of models served to represent equipment that was too large to display on the main stand of Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester. For example, there was a scale model of a 120MW, 3000 r.p.m. turbo-generator set typical of machines ordered from Metropolitan-Vickers for installation in British and overseas power stations. This model was cut away to show the details of internal construction.

The generator is hydrogen cooled, with longitudinal coolers fitted on the inside of the stator frame, and the rotor is direct cooled by hydrogen passing through slots in the rotor winding and in direct contact with the copper. The turbine is a three-cylinder reheat machine and illustrates recent advances in post-war turbine design, giving an output twice that of a three-cylinder 60MW unit of the immediate post-war period, although the overall dimensions are similar. An interesting point about this design is the rigid coupling of the rotors with a single thrust bearing located between the high-pressure and intermediate-pressure cylinders.

A 400 h.p. flameproof motor with two pole 3·3kV windings and sleeve bearings was one of the items of plant seen on the stand. It is fan cooled with separate internal and external air circuits. The machine (Fig. 74) is fitted with ring-lubricated sleeve bearings; above 400 h.p. the sleeve bearings have forced feed lubrication. The end brackets incorporate a special labyrinth seal consisting of concentric and complementary cylindrical sleeves which provide the required length of tortuous path between the inside of the machine and any inflammable atmosphere outside it. For satisfactory operation of the labyrinth seal the gland clearance on this machine requires to be checked periodically and kept between the limits of 0·029in and 0·041in by the use of shims.

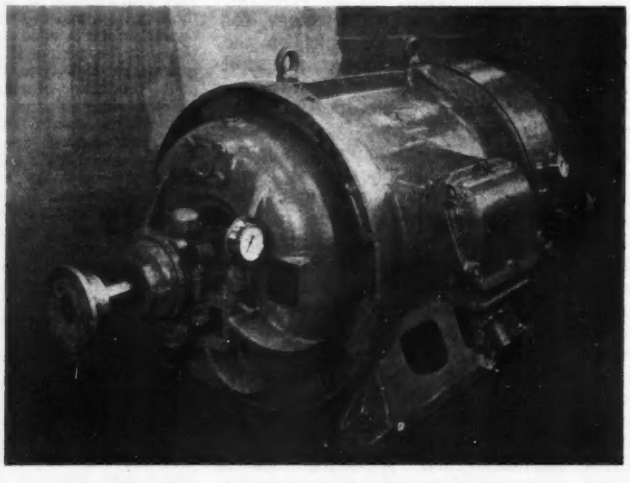


Fig. 74—400 h.p., 303kV, two-pole flameproof motor, type "FHSP" with sleeve bearings and labyrinth seal—Metropolitan-Vickers

Two examples of pumping equipment for vacuum systems were exhibited. One was the "Metrovac" 063D three-stage oil diffusion pump, which has been developed for operation in vacuum systems requiring high pumping speeds at low pressures; it normally uses "Apiezon-G" low-vapour-pressure oil as its working fluid. This pump has a mild steel shell which encloses a triple jet system made of aluminium. Cooling water is circulated through a helical coil of copper tubing, which is continuously soldered to the outside of the shell and which terminates in union connections. Vacuum seal is effectively maintained at both inlet and outlet connections to the pump by the use of a synthetic rubber "O" ring gasket compressed between the machined faces of mating flanges; a groove to accommodate the gasket is provided on each pump flange. A detachable heating unit comprising a "Metrovick" metal-sheathed radiant element, lagged and encased in a sheet steel cover, is attached to the base of the pump; standard heaters are rated at 1200W. Pumping speeds for air at pressures below 10^{-3}mm Hg are 600 litres per second (unbaffled) and 350 litres per second (baffled). The limiting pressure at 15 deg. Cent. is 1×10^{-5}mm Hg using "Apiezon-G" oil.

The other equipment, a "Metrovac" single-stage S24 rotary pump, was an oil-immersed vane pump. The casing and top cover are light alloy die castings, the bed-plate and belt guard are light steel pressings and the pump stator is machined from cast iron. The stator is inserted through an opening in the pump casing and is secured by a flanged joint. All joints in the casing are gastight so that exhausted gases may be collected. A simple oil baffle fixed to the underside of the top cover eliminates the undesirable oil spray and mist often formed at the exhaust connections of rotary pumps. The baffle and top cover are withdrawn together, giving clear access to the interior of the casing when cleaning. Besides the usual gravity drain plug a pressure drain connection is provided for use where gravity draining is impracticable. The pump is recharged with oil through the pressure drain connection and the oil level may be observed through a sight glass in the pump casing. The displacement is 2·4 litres per second at 475 r.p.m., ultimate pressure 10 microns Hg by McLeod gauge, pump shaft speed 475 r.p.m.

A recent addition to the Newton-Victor range of industrial X-ray equipments, the "Raymax 150," was also shown on this stand. It has been designed to meet the demand for a lightweight radiographic unit suitable for use in the factory or on an open erection site. It is stated to be the first gas-insulated X-ray equipment designed and produced in Great Britain, and makes use of sulphur hexafluoride (which is both non-toxic and inert and has a high dielectric strength) as an insulating material. The equipment consists of a tube head, gantry stand, control unit and water cooler.

Zwicky, Ltd.

A recent addition to the products of Zwicky, Ltd., Slough, Bucks, is the "Zwikleen" self-cleaning filter, a sectionalised illustration of which can be seen in Fig. 75. These filters are made in a range with from ¼in to 2in connections, and can be arranged for three stages of filtration with aperture sizes of 0·003in, 0·006in and 0·010in. The edge type filter element is built up of hollow steel discs separated by spacers of given thickness. Steel knives are arranged between the discs in such a way that a single turn of the external handle removes impurities which fall into the sump.

When the sump is removed from the assembly for cleaning, the complete element is withdrawn with it so that dripping from the element is avoided. The scraper blades are of substantial thickness to give rigidity, and they are stated to clean the whole depth of the element gaps and not just over the edges of the discs.

This firm also showed a new pressure-control valve and a pressure-regulating valve for oil burning and redesigned models of its mechanical lubricator and hand pump.

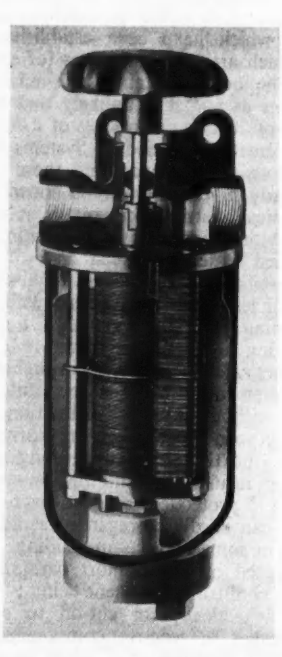


Fig. 75—Self-cleaning filter available for three stages of filtration with aperture sizes of 0·003in, 0·006in and 0·010in—Zwicky

Mono Pumps, Ltd., and Menrow, Ltd.

The main exhibit of the marine division of Mono Pumps, Ltd., 1, Sekforde Street, London, E.C.1, was a complete pressure system operating under shipboard conditions. It comprised 5-ton per hour pumps covering fresh and salt water supplies, with a common standby unit, all operating in conjunction with two 150 gallons pressure vessels. Automatic control of the entire pressure system is effected by a multi-motor control panel.

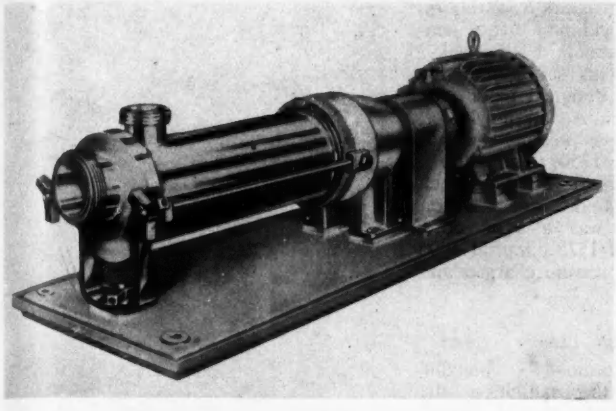


Fig. 76—Pump designed for easy dismantling for sterilisation. This pump is self-priming up to 25ft and has a capacity of 3000 g.p.h. with a maximum pressure of 30 lb per square inch—Mono

A new hygienic pump (Fig. 76) shown by the industrial pump division of the company is known as the "Kwikleen K63" and was used to demonstrate the quick and easy method of dismantling for sterilisation of the pump components. The pump is stripped in two simple operations with the aid of a combined screwdriver and tommy bar. All internal surfaces of this pump are polished stainless steel, and the stator is of a non-contaminating composition. The pump, which is self-priming up to 25ft and can be used for vacuum extraction duties, has a capacity of 3000 gallons an hour with a maximum pressure of 30 lb per square inch.

Menrow, Ltd., exhibited a dry oil-conditioning plant which is suitable for treating turbine and diesel engine lubricants, transformer, switchgear and industrial oils. It incorporates a pump, strainer, oil-water splitter, two dehydration chambers, a vertical filter press, an automatic drain sump, complete switchgear with automatic warnings, thermometer, and pressure gauge. This "M.1" multi-purpose treatment filtering unit (Fig. 77) has been designed to utilise the highly adsorptive qualities of modern granular media, to separate solid dispersants from fluid by filtration and to complete the treatment of oil by effective dehydration. The unit accommodates either filter cartridges or candle sets. Various types of media can be contained in the filter cartridges and the candle sets used are of ceramic composition for filtration or of metallic granular composition for oil dehydration. Interchange of these inserts enables the equipment to produce sterile liquids, or to carry out bacteriological filtration or general fluid purification. When fitted with "Menrow" filter cartridges the equipment can be used for the by-pass filtration of diesel engine lubricating oil or for the purification of diesel fuel oil on ships. It is stated to be equally efficient for conditioning either straight or detergent oils and will adjust acidity and remove acids, gums, tars, resins and asphaltenes.

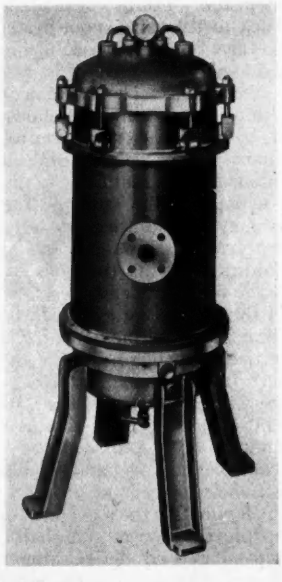


Fig. 77—Multi-purpose equipment for industrial filtration and oil dehydration—Menrow

Reavell and Co., Ltd.

The selection of reciprocating and rotary air compressors shown by Reavell and Co., Ltd., Ipswich, included one of the "SAT" range of reciprocating machines which are made in eleven sizes, for deliveries ranging from 3 cubic feet per minute at 2250 lb per square inch to 40 cubic feet per minute, 3000 lb per square inch. The "SAT 7" machine shown (Fig. 78) has a maximum delivery of 55 cubic feet per minute at a pressure of 2500 lb per square inch and is of three-stage, single-acting design. It has a first-stage piston of trunk design which is extended at the top to form the piston for the second stage, both pistons being operated from the same crank. The third-stage piston, operated from the other crank, is mounted in tandem above a circular crosshead of ample area which is arranged to take the side thrust of the connecting-rod. All pistons are provided with metallic packing rings designed to run for long periods without attention. The cylinder walls are of cast iron, those of the second and third stages being in the form of loose liners. All the valves fitted are of the featherweight low lift automatic type and are easily accessible for examination or overhaul. The first- and second-stage valves are flat disc valves and those of the third stage of the hollow thimble type.

The main casting which forms the crankcase and contains the first-stage cylinder and the guide for a third stage is of cast iron. A water jacket on the upper part of this casting incorporates recesses to accommodate the inter- and after-coolers. The two-throw crankshaft has the cranks set at 180 deg. and is carried on two renewable main bearings of die cast white metal in cast iron housings. A large oil sump is formed in the lower part of the crankcase casting and the crankshaft bearings and lower cylinders are splash lubricated by extensions on the connecting rods.

The three-stage oxygen compressor shown in Fig. 79 is capable of compressing 15 cubic feet of gas per minute to 2250 lb per square inch. These machines have their cylinders supported from the crankcase by a distance

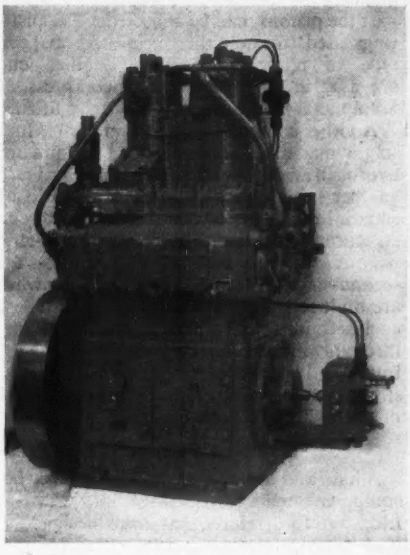


Fig. 78—Three-stage single-acting air compressor with a maximum delivery of 55 cubic feet per minute at 2,500 lb. per square inch—Reavell

piece and special provision is made to prevent crank-chamber lubricating oil from creeping up the piston rods and entering the compressing cylinders, where it might form an explosive mixture with the oxygen. The pistons are designed to operate with distilled water as lubricant and piston speeds have been kept very moderate in order to avoid overheating the gas.

The understructure is totally enclosed with automatic splash lubrication, as used in the firm's single-acting vertical compressors. The crankcase is of cast iron

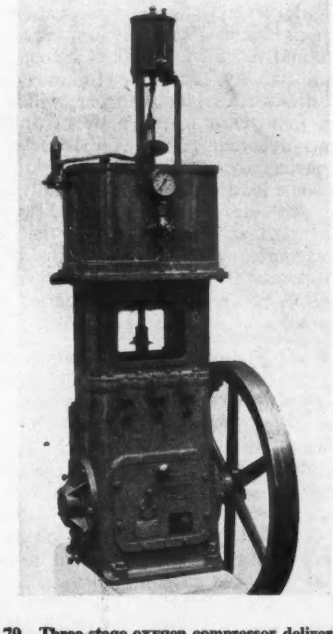


Fig. 79—Three-stage oxygen compressor delivering up to 15 cubic feet of gas at 2,250 lb. per square inch, and fitted with water lubricated pistons—Reavell

accurately machined for the crosshead guides and for the attachment of the inserted bearings.

The cylinders are housed in a removable water jacket, which also contains the cooling coils, and each cylinder is made of corrosion resisting bronze. The low- and intermediate-pressure cylinders are enclosed at the lower end and provided with a gland through which the piston-rod passes, in order that any small quantity of gas or distilled water, leaking past the pistons, can be collected. The piston rings used can be either metallic or a special type of reinforced plastics (leather cups are used in small low-pressure compressors). Solid metal high-pressure pistons are fitted.

Another compressor on the stand was a four-stage machine designed for compressing hydrogen and delivering up to 100 cubic feet of gas per minute at a pressure of 3500 lb per square inch. It is of two-crank vertical construction with the third- and fourth-stage pistons superimposed over the first- and second-stage pistons. The cylinders, which are built separately from the crankcase, are enclosed in a large rectangular steel tank through which the cooling water is circulated. Inter- and after-coolers of special coil construction are fitted on the machine because of the highly explosive nature of the gas.

Savage and Parsons, Ltd.

A load and torque measuring and recording equipment made by Savage and Parsons, Ltd., Watford, Herts, has been designed to give a continuous indication and direct writing pen record of applied load and/or torque in certain plant and machinery utilising rollers, such as rolling mills, in the chemical industries and for certain calendering operations in paper-making and in the manufacture of plastics and rubber. In this equipment d.c. energised strain gauge bridges are used for both load and torque measurements, and to ensure a continuous indication of each quantity over a protracted period a drift-free system of direct-coupled amplification is employed. The output signal from the gauge bridge is broken up by a transistor chopping circuit in the input stage so that an alternating quantity of a constant frequency of 400 c/s is applied to the amplifier.

The amplifier output is rectified and appears as a steady d.c. potential (for a steady loading), which is proportional to the input signal. Response is linear up to 40 c/s and overall feedback is incorporated for gain stability. A cathode follower output stage drives a current amplifier, which acts as an impedance match between amplifier and pen recorder. Two 3½in diameter, 6in scale meters are used to indicate torque and load. The load readings are normally taken from each side of the upper roller and the torque readings from each of the roller driving shafts, via slip rings. The overall feedback ratio is changed by relay when average torque or average load is required to be measured.

Ruston and Hornsby, Ltd., and Davey, Paxman and Co., Ltd.

The Ruston " TE " gas turbine, which was shown as a running exhibit coupled to a generator, was described in our issue of August 30 last. Another prominent exhibit of Ruston and Hornsby, Ltd., of Lincoln, was a new 0-4-0 diesel-electric shunting engine made by the firm. This locomotive is known as the " 200 DE " and is being built as an 0-4-0 weighing 30 tons, and an 0-6-0 weighing 32 tons. The 30-ton locomotive is stated to have a starting tractive effort of 22,000 lb.

The locomotive is fitted with a Paxman " 6 RPHL " engine, in which the cylinders are arranged in two banks of three at an included angle of 60 deg. It develops 210 b.h.p. at 1200 r.p.m., and is directly coupled to a B.T.H. d.c. self-exciting " RTB 6048 " generator, which supplies current to a double reduction, geared, nose-suspended traction motor geared to the rear axle of the locomotive.

The exhibits of Davey, Paxman and Co., Ltd., of Colchester, included four engines from the firm's well-known 7in and 9¼in bore series, which cover a power range of from 100 to 2000 b.h.p. One of the normally aspirated, eight-cylinder engines from this 7in bore range, with a Brockhouse torque converter, was shown as a standard " Drilpak " oilwell drilling set. This set is mounted on a skid base and is designed to develop 333 b.h.p. at 1350 r.p.m. A sixteen-cylinder, 7in bore engine shown was pressure charged: it gives 1000 b.h.p. at 1250 r.p.m., and a separate pressure charger is fitted on each of the two banks of cylinders. The largest engine on the stand was a 9¼in bore, " 12 YLCM " engine of 1575 b.h.p. at 1000 r.p.m., which is both pressure charged and intercooled.

Bryce Berger, Ltd.

In the Bryce " Speedlock " oil-engine governor shown at the exhibition the speed error is translated into a control movement in a rather novel way. An engine-driven positive-displacement pump forces hydraulic fluid (or fuel oil) through a nozzle and the jet impinges on a scoop. The thrust on the scoop is proportional to the square of the jet velocity (for a given fluid density), and the jet velocity itself is, of course, virtually proportional to engine speed. As shown in our illustrations, the scoop is mounted on a lever system and the reaction to the force of the jet is provided by a helical spring. For a particular spring setting, the position of the scoop, therefore, depends on the speed of the engine. Displacements of the scoop induced by fluctuations in engine speed are transmitted to a spool valve which controls the flow of oil to and from a double-acting cylinder. The latter drives the linkage regulating the speed of the engine.

The semi-schematic diagram in Fig. 80 illustrates the operation of the basic unit and some of its variants. Fluid enters nozzle *A* and the jet emitted strikes the scoop *B*. The chamber in which the scoop is mounted is filled with the fluid. A duct *C* leads the fluid from the chamber to the combined accumulator and relief valve *D*. Fluid pressure on the sleeve keeps the spring compressed sufficiently for the escape ports to be uncovered, permitting the fluid to enter the main housing. The fluid supplied through the duct *E* to the spool valve *F* is thus kept at a substantially constant pressure (100 lb per square inch). The scoop is fixed to a spindle *G* which works against a spring *H*. (For variable speed applications a pinion, quadrant and selector may be provided, as shown. In nominally fixed-speed installations knob

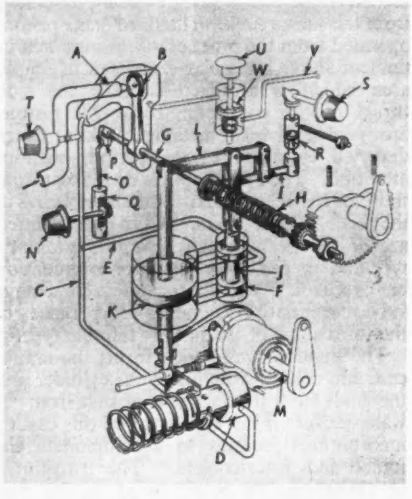


Fig. 80—The principle of the " Speedlock " governor is shown in this schematic assembly of its parts—Bryce Berger, Ltd.

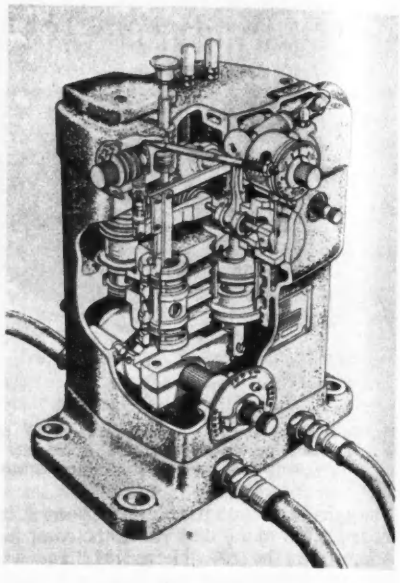


Fig. 81—Cutaway view of governor—Bryce Berger, Ltd.

T operates a needle valve by-passing the nozzle, and this provides a 10 per cent adjustment of speed ; a bolt and locking nut hold the spring setting.) The lever *I* is fixed to the spindle *G* and linked to the spool valve *J*. Displacement of the latter admits fluid from duct *E* to one side of the relay piston *K* and permits the release of fluid from the other side into the housing. In the diagram it is apparent that an increase in engine speed will lead to clockwise rotation of spindle *G* and the consequent elevation of the relay piston. The rise of the relay piston is fed back to the valve spool by the arm *L* until the valve ports are closed again and the motion ceases. The converse happens when engine speed falls. The movement of the relay piston is transmitted, as shown, to the shaft *M*, by which the engine control linkage is actuated. The speed droop of the governor is determined by the stiffness of the spring system acting on the spindle *G* and this stiffness may be adjusted by turning the knob *N* to raise or lower the leaf spring *O*. It is claimed that the droop is accurately controllable between 2 and 10 per cent. The angle of the radial face *P* on which the leaf spring bears is set during assembly in such a position that a change in droop setting will not affect full-load engine speed ; in the full-load condition the force from the leaf spring always becomes zero. An adjustable damper *R* is provided for stabilisation : control knob *S* operates the cam that positions the stop in the cylinder of the damper. By limiting the movement of lever *I*, this stop prevents the output shaft *M* from being moved beyond the position fixed by the setting of the control knob. The latter is calibrated in terms of percentage to correspond to the similar calibration at the output

shaft (see Fig. 81). Manual depression of knob *U* mechanically displaces the valve spool downwards, and full controlling force to stop the engine results. Stopping from a remote control point is also possible by venting duct *V* (normally closed to that bleeding through piston *W*), causing a pressure drop and the consequent downward movement of the piston. A spiral spring on the output shaft *M* can be provided, as shown, to over-ride the dormant servo-amplifier if pump pressure fails, so shutting off the supply of fuel to the engine.

The governor as a whole (see Fig. 81) may be bolted in any attitude to any suitable part of the engine ; it does not, of course, require a mechanical drive. The maker states that it can absorb up to 12 gallons per minute at 150 lb per square inch, optimal performance being obtained at 8 or 9 gallons per minute. The total angular range at the output shaft is 40 deg., and the nominal (stalled) output torques are 27 lb-ft to open and 67 lb-ft to close (the difference is due to the safety spring; if this is omitted the torque is 47 lb-ft in both directions). A cooler may be built into the base and requires a water supply at a pressure not less than 5 lb per square inch and a temperature not greater than 130 deg. Fah. The controlling unit is said to be suitable for most engines of between 500 h.p. and 5000 h.p., and to govern satisfactorily over a speed range of 8 : 1.

Alley and Maclellan (Polmadie), Ltd.

One of the air compressors shown on the stand of Alley and Maclellan (Polmadie), Ltd., is illustrated in Fig. 82 and is representative of the 56 B.9 two-cylinder horizontal machines, which are made in a range of sizes delivering from 400 to 2000 cubic feet per minute at up to 150 lb per square inch. Vacuum pumps of the same basic design are available with displacements up to 3000 cubic feet per minute.

In these compressors the two cylinders are opposed to one another with the crank-throws set at 180 deg.; all the reciprocating parts are so designed that the opposing masses are equal and there are no horizontal out-of-balance forces. This design enables foundation requirements to be reduced to a minimum, and if necessary a compressor can be operated successfully on skids alone. With the 180 deg. crankpin arrangement the main bearings are called on to deal only with the small horizontal forces resulting from the couple, and the load of compression and the inertia forces cancel each other out.

The stator of the compressor driving motor is flange-mounted on to the crankcase and the rotor, which is fitted directly to the solid crankshaft, also serves as a flywheel. An oil cooler, intercooler, &c., are all built directly into the unit. The intercooler is situated below the motor and this gives an extremely compact compressor which occupies approximately the same area of floor space as an equivalent vertical compressor.

Kerry's (Ultrasonics), Ltd.

Three types of ultrasonic cleaning plants shown by Kerry's (Ultrasonics), Ltd., Wharton Road, London, E.15, included two of small capacity—one with a high and the other with a low-frequency generator—and a large high-frequency model. The firm states that during the past year its ultrasonic drilling equipment has been extensively developed for machining a variety of materials. It can now be used effectively for machining such materials as germanium, tungsten carbide, ceramics and precious stones. Of particular interest is the fact that it is now possible to machine threads in hard and brittle materials on the equipment to close tolerances and in a relatively short time.

As is now generally known, the equipment consists of a drilling unit and an ultrasonic generator supplying alternating current at 20,000 c/s to the winding of a magneto-strictive transducer, which converts the electric power into mechanical vibrations of the same frequency. This transducer is attached to metal coupling stubs, which transmit the vibrations to the working face of a cutting tool of soft material, such as mild steel or brass. An abrasive slurry interposed between the tool and the workpiece is used for cutting the work. A number of typical workpieces machined by this process were to be seen upon the stand.

Atlas Copco (Great Britain), Ltd.

The tools and other pneumatic equipment displayed by Atlas Copco (Great Britain), Ltd., Beresford Avenue, Wembley, Middlesex, included an air hoist for use in marine engine-room maintenance. This hoist has a capacity of 5 cwt and is driven by a radial piston air motor, which gives a stepless speed control up to 34ft per minute when raising a load.

A new compressor for shipboard installation has a free air delivery of 293 cubic feet per minute at a pressure up to 120 lb per square inch. It is designed to run at 870 r.p.m. and when delivering air at 100 lb per square inch required a drive of 65 b.h.p. The two low and one high-pressure cylinders are arranged in " W " formation and annular valves are fitted. The valve seals and guards have integral spindles of high alloy steel, and special heat-treated alloy valve and buffer plates are lapped to a high finish on both faces. A single-crank, drop-forged crankshaft is carried in self-aligning roller bearings, and the connecting-rods have white-metal-lined big-end bearings and lead-bronze gudgeon pin bearings. A pressure lubrication system is fed by a gear pump at one end of the crankshaft, and a fan-cooled intercooler is mounted on the machine.

A pneumatic shearing tool exhibited weighs only 5¾ lb and is designed to cut 0·080in mild steel sheet at a speed of 20ft per minute. This tool is driven by a vane air motor and a tubular inlet valve keeps pressure losses to a minimum. A silencer is built into the body of the tool and the motor is supplied with oil by an automatic lubricator, also incorporated in the body.

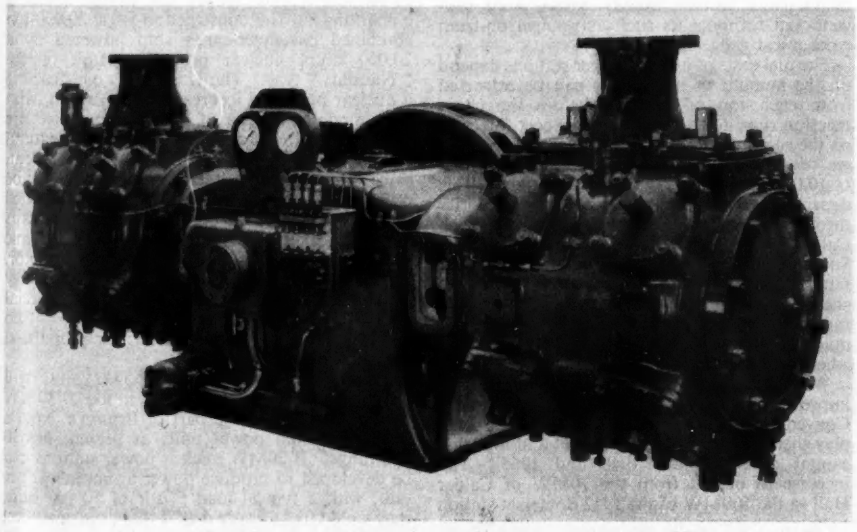


Fig. 82—Horizontally-opposed compressor—Alley and Maclellan

The 1959 Exhibition

The next Engineering, Marine, Welding and Nuclear Energy Exhibition is being arranged to take place at Olympia from Thursday, April 16, to Thursday, April 30, 1959. It will be the twenty-second in the series, and will be the first to be held at a time of year other than late summer or the autumn. In announcing a departure from a long-established custom, the organisers, F. W. Bridges and Sons, Ltd., express confidence that the change to the last fortnight of April will meet with the approval of all concerned.

Building Research

THE comment has often been made that some sections of the building industry are too conservative, and do not readily adopt methods of working which recent researches have shown to be advantageous. The Building Research Station's annual report for 1956, which has just been published, has some encouraging remarks to make on this situation. Although problems of application are more than usually acute in the building industry, the report states, due partly to its size and diversity, the Station exercises a large influence. About one-third of its effort is directed to advisory services and *ad hoc* problems, and the close contacts in the industry which it has established are effective, the report affirms, since the Station sets out to understand the outlook and practical problems of those engaged in the industry.

Fundamental research in cement chemistry, aimed at extending knowledge of the cementing compounds present in cement, has been prominent at the Station for some time. A recent development in technique is noted, namely, the use of a high temperature microscope devised at the Station for observations at high magnifications up to 2000 deg. Cent. The mechanism of drying shrinkage in concrete is also being investigated.

Amongst engineering matters which were the subjects of researches in 1956, an investigation into the bearing capacity of groups of piles is noteworthy ; further work on the stability of clay banks retaining water is also recorded. An interesting structural study, the commencement of which is noted, involves the concrete shield of the fourth reactor now under construction at Calder Hall. Instrumentation has been installed in the shield to measure strains, temperatures, joint-openings and moisture. A preliminary survey of the structural problems in designing a roof top heliport has also been made.

Future of Atomic Energy

On Thursday, September 12, in the course of the International Conference on Radio-isotopes, Sir John Cockcroft delivered an evening lecture under the above title. Sir John, who is director of the Atomic Energy Research Establishment at Harwell, had been elected president of the Conference, which is now taking place in Paris. The greater part of his lecture is given below.

AT a meeting of the 1955 Geneva Conference on the Peaceful Uses of Atomic Energy, I was bold enough to deliver an address on the future of atomic energy. I have been asked to appear once again in the role of a prophet, and I will try to describe how these visions of the future have changed during the last two years. At Geneva our economists and statisticians predicted that the world's total energy requirements would increase by about one and a half times by 1975, and by three times by the year 2000. To meet this enormous increase in the demand for energy, rising to the equivalent of seven milliard tons of coal a year, it will be necessary to make the fullest use of potential hydro-electric resources, which are capable of doing the work of one milliard tons of coal a year, and also to call on nuclear energy to provide most of the rest of electricity supplies, doing the work of two to three milliard tons of coal a year, leaving coal and oil to provide the rest. In the middle distance of 1975, electricity production was predicted to increase about four times over the 1955 level—from 1500 milliard kWh to 6000 milliard kWh—requiring the equivalent of three milliard tons of coal.

During the last two years the countries of Western Europe have taken stock of their energy requirements and have realised that, since their coal production is increasing very little, their increased energy requirements would require very large increases in imports of coal and oil. Thus, if nuclear energy were not developed, the six Euratom countries foresaw their bill for fuel imports rising from 2 billion dollars a year in 1957 to six billion dollars in 1975. Without the development of nuclear energy in the United Kingdom, fuel imports for electricity production might increase by up to about £350 million. The Euratom countries have therefore prepared a plan to install 15,000MW of nuclear power stations by 1967. The United Kingdom Government has decided to build nuclear power stations having a capacity of 5000MW to 6000MW by 1965, these stations to do the work of 18,000,000 tons of coal a year and reduce our fuel imports correspondingly.

By 1975 the Euratom plan would save 100 million tons of coal equivalent a year, and the United Kingdom nuclear power development may well save 40,000,000 to 50,000,000 tons of coal equivalent.

The situation in other Western European countries is rather similar, though the time at which nuclear power will become important depends on the date at which hydro-electric supplies are fully utilised. Thus, Sweden now obtains three-quarters of its energy from imported fuel at a cost of 17 per cent of its total import bill. On the other hand, Swedish hydro-electric resources will not be fully exploited until 1968-70, so nuclear power development is less urgent.

In the U.S. and U.S.S.R., abundant supply of conventional fuels and unexploited hydro-electric capacity will delay very large scale exploitation of nuclear power. The latest forecast predicted 3000MW to 4000MW for the U.S. by 1965, and 1500MW for the U.S.S.R. by about 1961.

In Asian countries, Japan is in a similar situation to Western Europe; India has great resources of hydro-electric power, and will only require nuclear energy in regions remote from hydro supplies; some Middle Eastern countries like Iraq have immense indigenous oil supplies, and are hardly likely to be interested in nuclear power this century.

In Africa, the great hydro-electric schemes at Owen Falls and Kariba Gorge, and the Volta scheme of the Gold Coast, together with abundant coal in other areas, mean that nuclear power applications will be limited in scope during the next two decades.

In Oceania, hydro-electricity is abundant in the South Island of New Zealand, and coal is abundant in many parts of Australia, though nuclear power may be important in mining areas and in South Australia by 1965.

By 1965, then, nuclear power will be developing rapidly in Western Europe and more slowly elsewhere.

In Great Britain the nuclear power plan is already being translated into concrete and steel, and three nuclear power stations of about 300MW output each are being built for completion in 1960/61. A Somerset station of 500MW output will follow by 1962,* and at least eight further great stations by 1965. In these plans, and those announced in other countries, two types of nuclear reactors seem likely to play the major role. Britain is basing the first stage of its programme on the gas cooled, graphite moderated, reactor; the United States and U.S.S.R. are building their first full-scale nuclear power stations with pressurised water reactors. The first United Kingdom nuclear power stations are characterised by rather high capital costs, but low fuel costs resulting from the use of natural uranium. The United States pressurised water reactors have lower capital costs, but higher fuel costs due to their use of the more expensive enriched uranium fuel. The relative economies of the two types of power units vary in different countries, depending on the cost of labour, the interest charges and method of financing. Thus the gas cooled, graphite moderated, reactor will produce electricity more cheaply in the U.K. than it would in the U.S.

Future Technical Development and its Effect on Power Station Costs

Capital costs of the gas cooled, graphite moderated, reactor in particular are likely to fall rapidly with foreseeable increases of ratings and fuel temperatures of reactors, and Sir Christopher Hinton has predicted that nuclear power costs will fall 30 per cent in the decade from 1960-1970, whilst on previous trends the cost of power from coal-fired stations may rise up to 10 per cent in this period. We in Britain have by now had fifteen months of experience of operating the Calder Hall nuclear power station, which produces 70MW of electricity using two nuclear reactors as a source of heat. Our experience in operating this power station has so far been very good, better indeed than most conventional power stations. There is in fact little to go wrong in the nuclear parts of a power station except the uranium fuel elements. Any maintenance trouble usually comes from conventional components such as pumps, or from mechanical gadgets.

The fuel costs of nuclear power stations depend on the amount of heat which can be extracted from each ton of uranium before the chain reaction runs down. We base our cost forecasts on the assumption that from each ton of uranium we will be able to extract the heat equivalent of 10,000 tons of coal in the 1960 stations. This depends on fuel elements retaining their integrity throughout a life of four to five years. Each Calder Hall reactor contains 10,000 fuel elements. So far only three fuel elements have developed faults, usually tiny cracks in the walls of the sheathing metal that lead to a small escape of radioactivity into the gas stream. This is detected quickly and the fuel elements can be changed when convenient.

We can foresee the possibility of steadily improving this type of nuclear power station. Conventional engineering improvements will play their part in increasing output and lowering capital costs between 1960 and 1965. The increase in output from the 70MW of Calder Hall to the 500MW of the 1962 Somerset station is an example of this process. We can also foresee a further major improvement in performance by changing from metallic fuels to ceramic fuels, such as uranium oxide, by the mid-1960s. These have the great advantage of withstanding higher temperatures, and they also resist radiation damage better than metal. These two factors should enable heat ratings and efficiency and burn-up to be increased, leading to lower capital costs and lower fuel costs. We can also foresee that, by 1965–70, recycling of plutonium fuel will be well established, and that plutonium may be recycled with thorium as a fertile material to lead us into the thorium fuel cycle, which is likely to have better nuclear characteristics than the uranium fuel cycle for thermal reactors. Our experience of radiation damage of plutonium-enriched fuels in some carriers has been very favourable. We can predict, then, that thorium resources will, from 1970 onwards, powerfully reinforce the energy available from uranium resources.

At the Geneva Conference, Mr. Jesse Johnson said that in seven countries alone there was available 1,000,000 tons of uranium, and that the price of uranium oxide would fall towards 10 dollars a pound by 1965. Since then, many more important uranium deposits have been found, especially in Canada, and supplies of well over 30,000 tons a year of uranium oxide are assured, whilst prices seem likely to fall even lower than Mr. Jesse Johnson's 10 dollars a pound.

If the Euratom plan is fully implemented, the annual burn-up of European and United Kingdom nuclear power stations in 1975 might require about 5000 tons of uranium a year, if plutonium recycling is by then in full swing. Another 5000 tons of uranium a year would provide for the initial fuel charges of about 5000MW of new installations a year. These requirements would be reduced by improvements in the neutron economy of reactors, or by the successful introduction of breeder reactors. Britain is now building in the North of Scotland, at Dounreay, a 60MW (thermal) fast reactor experiment designed to solve the technological problems of highly-enriched fuel breeder reactors. We expect this to be commissioned in 1958, and we will accumulate experience in the formidable technological problem of the fast reactor during the course of the following two or three years. If we can solve these problems economically, we would expect that plutonium from our thermal reactor power stations would begin to be used as fuel for breeder power stations by the 1970s, and that the installation rate of breeders would then be adjusted to the output of the thermal stations.

Smaller Power Units

The application of nuclear power to ship propulsion and to smaller land stations is also making progress. The United States nuclear submarine, "Nautilus," has a remarkable record of trouble-free performance in steaming over 60,000 miles, and already the United States is embarking on the construction of a 20,000-ton combined passenger-cargo ship powered by a 20,000 s.h.p. nuclear propulsion unit of the "Nautilus" type. The U.S.S.R. is constructing a nuclear propelled icebreaker. In Britain, with only modest supplies of enriched fuel, we are studying the application of reactors using natural uranium fuel or fuel of only low enrichment, since these reactors seem more likely to be economic than reactors using highly enriched fuel. A tanker of the 40,000–60,000-ton class is the most likely candidate for quasi-economic nuclear propulsion, since it has a high load factor. In addition to the large nuclear propelled navy of the U.S., we can foresee prototype commercial ships sailing the ocean by the mid-1960s, but no great turnover to commercial nuclear propulsion till the 1970s.

These comparatively small power units will have application to land stations in the 20/30MW output range. A large part of Britain's exports of conventional power units at present lies in this range. If 20MW nuclear power stations can be developed to produce power at about 1d. per unit, with a typical load factor of 50 per cent, they would find a ready use. I think the prospects for these are good by the mid-1960s. This type of power station will find application in the

* Sir John is here referring to Hinkley Point. The contract for this station has just been awarded, and a report appears on page 415.

so-called under-developed countries, and in remote mining areas where power costs are abnormally high at present—as much as 3d. per unit in places like Broken Hill.

If we look still further ahead we see the glittering prospects of releasing energy from controlled thermo-nuclear reactions. If deuterium, or a mixture of deuterium and tritium, is heated up to a temperature of two or three million degrees, nuclear fusion reactions will occur, helium will be formed, and neutrons will be emitted. The gas can be heated and made highly conducting by a powerful electrical discharge either in a torus or in a straight cylindrical tube. The technical problem is how to insulate the hot plasma from the walls of the container so that conduction losses become unimportant. The experimenter is helped by the constrictive action of the magnetic field produced by the current carried by the plasma. This pinches the plasma into a filament. The filament, however, is unstable—it tries to turn itself into a helix, and wriggles so that the experimenter has to apply additional magnetic fields as a stabilising mechanism. In a practical thermo-nuclear reactor, the energy output must exceed the energy input. Radiation losses increase slowly with temperature, whilst the release of fusion energy increases very rapidly. For energy output to exceed energy input, temperatures of about 50,000,000 deg. are required. These are likely to take a long time to achieve. Neutrons have already been observed by several groups of experimenters working with straight tubes in the U.S.S.R., U.S., and in this country, but these have been shown to be due to conventional accelerating processes by strong electric fields, and not to arise from high-temperature plasmas. It is sometimes difficult to be sure of the origins of neutrons in this work ; nevertheless, it is likely that temperatures of a few million degrees will be achieved shortly and, with these, fusion reactions will be produced by high-temperature plasmas. A torus known as ZETA has recently been put into operation in Britain with the object of reaching temperatures of several million degrees. The results are promising, but require time for interpretation.

By-Products and Safety

The large scale development of nuclear power in the world presents us with new safety problems, and problems of radiological control. These are now receiving a good deal of attention in Britain and the United States. Designers and operators of nuclear reactors are very conscious of the fact that millions of curies of fission products are locked up in the fuel elements, and that over-heating and melting of the fuel elements would release these fission products into the reactor circuit. The reactor design and codes of operation must ensure that temperatures cannot rise sufficiently to melt fuel elements ; secondly that, even if melting takes place, the products are contained within the reactor circuit or a containing shell. Research on safety problems is important and is being carried out intensively in the U.S. and U.K. We also have the problem of concentration and storage of the radioactive waste products from the chemical separation plant where fuel elements are processed. In Britain, we now evaporate our waste products to small volume, and store these in stainless steel tanks. By 1960 we hope to be extracting the long-lived radio-cæsium to produce radioactive sources on the megacurie scale for use in industrial processes. This will help the problem of storage of the remainder. Other fission products, such as the radioactive gases, are beginning to be extracted and stored and used for industrial purposes, helping thereby to reduce the contamination of the atmosphere.

The use of these large sources of radio-isotopes is now being studied actively in many countries. In Britain we have founded the Wantage Radiation Laboratory as a close satellite of Harwell, to carry out such studies. The Laboratory is now equipped with sources of radio-cobalt of up to 10,000 curies, and hopes in due course to equip itself with radio-cobalt sources of half a million curies, and later on with still more powerful radio-cæsium sources. These sources will be available for research by industry, Government departments and Atomic Energy Authority staff, into application of radiation to chemical processes, to food preservation, to sterilisation, and to other problems.

Industrial Uses of Radiation

At the Wantage laboratory we are investigating many possible uses of radiation to industry. The majority of this type of work has been done in the U.S.A., where millions of dollars have been spent on investigations on food preservation or the extension of storage life of food. They have found that the storage life of bacon, ham and sausages can be increased by a factor of 4 or 5. To increase the storage life further would necessitate such big radiation doses that unwanted side effects such as unpleasant taste and flavour would be noticeable. Scientists working on food preservation are now more and more adopting combined methods of preservation using radiation, plus light cooking of the food or an addition of antibiotics. These combined operations look very promising.

Radiation may also contribute to insect control. We heard at the Geneva Conference of the spectacular work on the elimination of the Screw worm by the irradiation of the male flies. We are working now on grain disinfestation, a serious problem in some of the grain producing countries. Although doses of 50,000 R are necessary to kill insects, much smaller doses suffice to make their eggs infertile.

Radiation is already playing a new role in medical sterilisation, and may be of great importance to the treatment of antibiotics. The importance of radiation to plant breeding is emphasised in a recent report of the Economic and Social Council. The contribution that radiation makes to plant breeding is that it vastly increases the frequency of appearance of mutations—by fifty or one hundred fold or more—and so provides a relatively simple means of greatly expanding the variability available to the plant breeder for selection.

Some of the physical changes which radiation may produce are well known. Polyethylene can be cross-linked by radiation, and the resulting polymer can stand up to higher temperatures. Polyethylene melts at 110 deg. Cent., but when irradiated with doses of roughly 107 R can stand up to 150 deg. Cent., a very important feature for the electrical cable industry.

At present industry is trying to find new useful radiation-induced polymerisation products. Vulcanisation of rubber is generally carried out by using sulphur as the link between different atoms. By using radiation this link may be established without introducing a new element, and the resulting product has therefore much better temperature-resistant properties. So tyres are claimed to last longer. Radiation energy may be used to make chemicals at present produced by high pressure and temperature, or may even be able to give us new compounds.

The use of massive radiation is very new, in fact newer than atomic energy itself. The development is therefore in its infancy, but I believe that the use of radiation may be of very great importance, and engineers of future atomic power reactors may be well advised to think about the practical aspects of using some of the immense amount of gamma radiation at present unused, which is locked up in these plants.

I feel somewhat diffident in speaking about the application of radio-isotopes to industry in the presence of Dr. Libby, who has given us so many excellent lectures on this subject. However, I cannot miss the opportunity of quoting his estimate that U.S. Industry and Agriculture is already saving half a billion dollars a year by the use of radio-isotopes—at a cost to the U.S. Government of about 3,000,000 dollars. This is a remarkable example of the multiplying and catalysing effect of research. However, still greater advantages are predicted in the future and Dr. Libby predicts that the saving will rise to 5 billion dollars a year by 1960. An interesting example mentioned by him is the use of radio-isotopes to facilitate oil-well stimulation. This application alone is saving 180 million dollars a year to the oil industry. Dr. Libby sees also a great extension of process control by labelling with carbon-14 important contributions such as octane going into an oil refinery. This will be done with very low levels of activity since the initial carbon-14 content is very nearly zero.

I might also mention the important contribution which radio-isotopes, produced in large quantities for us by weapon trials, are making to studies of the circulation of the atmosphere, particularly north-south mixing, and also to oceanography.

The potentialities of our newly-won access to the inexhaustible energy of the atomic nuclei are enormous. It could be used to destroy our whole civilisation. But if we justify our status of *homo sapiens*, and manage by a combined effort of the human race to avoid this, it cannot fail in the long run to provide enormous benefit to mankind.

Acceptance Tests for Steam Generating Units

A code for acceptance tests for steam generating units has been published by the British Standards Institution.* Its purpose is to establish the procedure for acceptance tests on stationary steam generating units for power stations and for presenting the test results in tabular form. Primarily the code is intended for conventional units having natural circulation, but it can be used, where applicable, with other kinds of steam generating units. The provisions apply to equipments fired by solid fuel (mechanical stoker or pulverised fuel), gas or oil, but not to waste heat boilers, which are dealt with in B.S. 1307. The code gives the procedures for the determination of thermal efficiency by direct measurement of heat input and heat output and for the determination of the losses in the products of combustion and the residue. Directions are given for the evaluation of the efficiency by the heat-loss method, for use in instances where it is impossible to measure the heat input or output within acceptable limits of accuracy. There is provision in the code for the evaluation of the performance of the draught plant and pulverisers and for the measurement of steam purity, for use in cases where tests are required to demonstrate compliance with the provisions of a contract. Many specimen " standard forms " are included in the code.

The subject of tolerances is considered to be outside the scope of the code, but it is suggested that the probable errors involved in doing a test may be assessed by using established statistical methods to combine the individual errors likely to arise from the separate measurements.

It is stated that the companion publication, B.S. 845, " Code for Commercial Acceptance Tests for Steam Boilers," will eventually be revised to bring it into line with the new code, B.S. 2885, and to meet the special requirements of smaller plant.

Preliminary Work on Nuclear Power Station at Hunterston.—Preliminary work has begun at Hunterston, Ayrshire, where The General Electric Company, Ltd., is to build a gas-cooled, graphite-moderated, nuclear power station for the South of Scotland Electricity Board. The contract was awarded in December, 1956. Constructional work on the two reactors and the associated steam-raising plant is to be performed with the aid of a Goliath crane claimed to be the largest of its kind in the world : with a span and height of 200ft, it is said to be capable of lifts up to 350 tons. Erection of the turbine hall and installation of the six 60MW hydrogen-cooled turbo-alternators will proceed in parallel with the construction of the reactors. The preparatory excavation of over 160,000 cubic yards of soil and rock is to be followed by fabrication on site of the welded 70ft spherical pressure vessels that are to enclose the reactor cores. The walls of the vessels are to be of 3in plate, and are designed to withstand 150 lb per square inch. The reactor cores are to be roughly cylindrical, with diameters of 50ft 6in and heights of 28ft. Two thousand tons of machined graphite bricks and tiles are to go into each core, and it is stated that almost surgical cleanliness will be required to align the 3288 vertical fuel channels correctly. Cylindrical pressure vessels 19ft 6in diameter by 73ft 6in high are to enclose the sixteen steam-raising units, each of which is to contain about 14 miles of finned mild steel tubing.

* B.S. 2885 : 1957. Published (price 12s. 6d.) by The British Standards Institution, 2, Park Street, London, W.1.

Thermostatic Valve for Cooling Water Systems

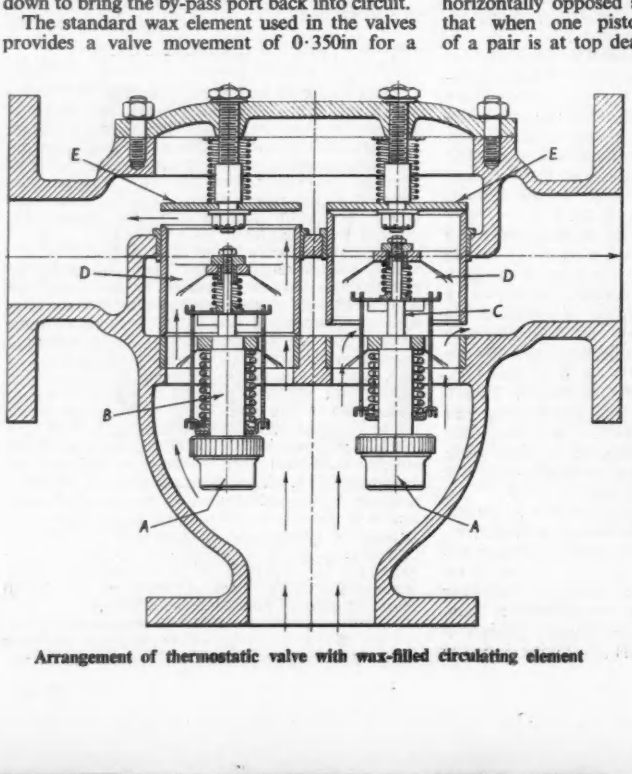
A THERMOSTATIC valve now being made by Teddington Industrial Equipment, Ltd., Sunbury-on-Thames, is designed to provide a sensitive and reliable control means to maintain the temperature of cooling water in heavy duty diesel engines within close limits. These valves are in no way sensitive to circulating pump pressure. They are of three-way construction and can be used either as diverters, to provide a means of rapidly warming up an engine from the cold condition and maintain the water jacket outlet temperature within predetermined temperature limits, or as mixers to control the temperature of the lubricating oil supplied to the bearings.

The operating medium incorporated in these valves is an element in which there is sealed a special wax which reacts to temperature changes. On the temperature rising beyond a predetermined level, this wax expands and forces upwards a flexible sealing diaphragm at the top of the element. Typical valve arrangements with the elements in their non-operative and operative positions can be seen in the accompanying drawing. In the valve on the left the cooling water is passing from the bottom up through one delivery port of the valve, and in the valve on the right out of the other port.

Each wax filled element *A* at the foot of the valve actuating assembly is rigidly connected through a cylinder *B* to the body of the valve, with the flexible diaphragm of the element registering in the bore at the lower end of the cylinder. A spring-loaded piston *C* in this cylinder is connected through an extension to a cylindrical valve member *D* which is slidable in the body and provides a partition between the two outlet ports. The normal flow of cooling water circulating through the engine passes through the centre of the cylindrical valve to the outlet port, as shown by the arrows in the valve on the left-hand side of the drawing.

When the temperature of the cooling water increases beyond a predetermined limit, the wax in the element expands and pushes the diaphragm up into the cylinder bore. This movement forces the piston up, against the load of the return springs, to raise the cylindrical valve, the top rim of which then seats against the spring-loaded sealing plate *E*. This stops direct circulation to the engine and diverts the coolant, as shown on the right in the drawing, to pass through the other port of the valve. This port passes the cooling water through a heat exchanger in which the water is cooled before recirculation in the engine cooling system. When the temperature of the water has been lowered, the wax cools and, as its volume decreases, the return spring draws the cylindrical valve member down to bring the by-pass port back into circuit.

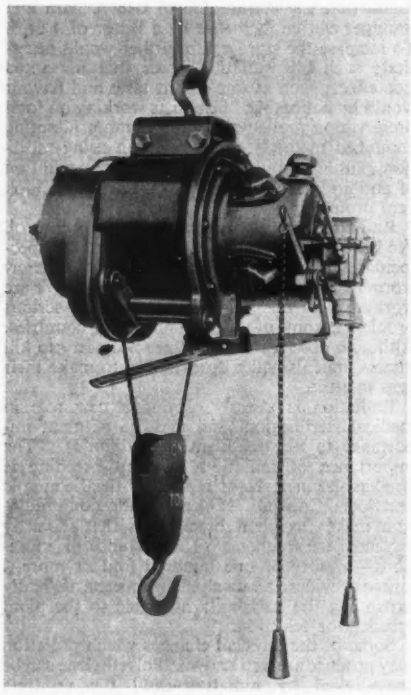
The standard wax element used in the valves provides a valve movement of 0·350in for a temperature change of 25 deg. Fah. These "Waxtrol" valves, as they are known, are available with a range of alternative temperature settings and are at present being made in a range of sizes from 1¼in to 4in.



Arrangement of thermostatic valve with wax-filled circulating element

Air-Driven Hoist

AN air-driven overhead hoist now being manufactured by Ingersoll-Rand, Ltd., is illustrated on this page. This hoist is hand operated by chain and lever in conjunction with a spring-loaded, poppet-throttle valve, which gives a positive and sensitive control. When the air motor is reversed, a graduated reversing valve prevents snatch and ensures smooth motion.



Compressed-air-driven hoist of 1-ton capacity and a maximum lift of 15ft

The air motor is of radial construction with two pairs of cylinders horizontally opposed so that when one piston of a pair is at top dead centre the other is at bottom dead centre.

The cylinders, which are renewable and interchangeable, are spigoted into the crank chamber, and each piston is mounted on a solid drop-forged connecting-rod. The driving shaft passes through the centre of the hoist drum, which it drives through spur reduction gears enclosed within an oil and grease chamber.

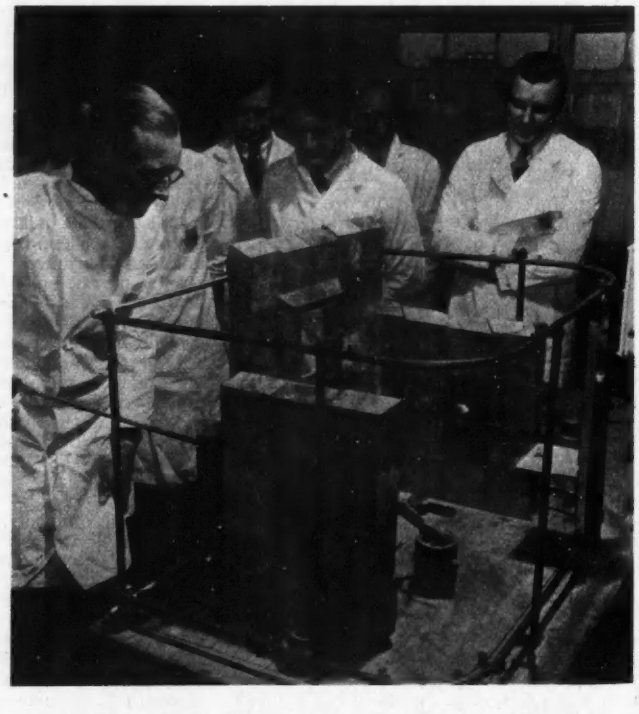
An anti-friction bearing is provided for the swivelling top hook, and there are automatic safety stops to prevent over-travel as well as an automatic brake.

The block illustrated has a direct lifting capacity of 1 ton and a maximum lift of 15ft. Its weight inclusive of the top hook is 355 lb, and an alternative to the top hook is a four-wheeled trolley for beam mounting purposes.

Laboratory Equipment for Work with Radioactive Materials

A RANGE of leaden shielding bricks is manufactured by Savage and Parsons, Ltd., Watford, Herts. These can be used to build walls for the protection of persons experimenting with radioactive materials, as shown in our illustration. The bricks interlock in a manner ensuring that no straight path is offered for radiation to traverse. No jointing material is required and both assembly and dismantling are claimed to be easy. Thicknesses of 4in and 2in are available. Interlocking concrete bricks are offered for use where radioactive or toxic materials have to be stored. Special bricks are provided with rotatable spherical inserts in which manipulators may be mounted. Other variations are bricks with apertures (closed by leaden bungs) providing access for "glove boxes" where manual handling is necessary, and bricks with adjustable mirrors or solid lead-glass blocks in leaden frames to permit viewing.

Isotope transporting cans made of lead are also marketed by the company. These containers are said to have been made to the design and specification of the U.K. Atomic Energy Authority. They offer differing degrees of protection for various applications, and are shaped to ensure uniform thickness of shielding round the source of radiation. Riveted clasps, carrying handles, label frames and sponge rubber liners are fitted where required. Can-handling and opening tools are also available, as well as other equipment for remote handling.



Interlocking leaden bricks form a wall 2in thick in this scene at Harwell. The use of handling equipment is being demonstrated to students. The lead container visible under the tongs is of a type used for the transport of isotopes in this country and abroad

Overhead Crane Erection Problem

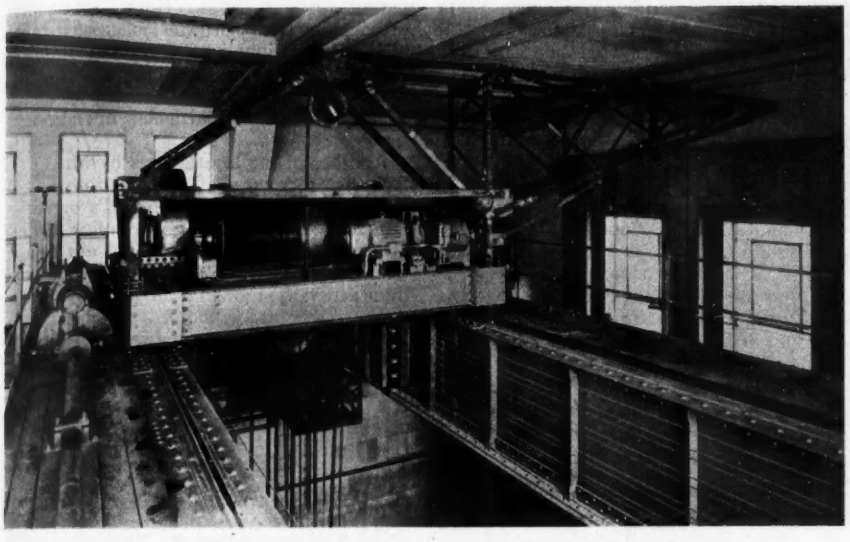
PARTICULARS have been received from Mr. E. J. Leopard, director and works manager of the Reed Crane and Hoist Company, Ltd., Fishponds, Bristol, of the way in which a number of structural difficulties were overcome in erecting supplementary crane equipment in a power station. This work was carried out in the turbine house of the Brighton " B " power station, where extensions had made it necessary to increase the capacity of the originally installed 80-ton overhead travelling crane to 95 tons. To effect this increase it was decided to install a second crane of 20 tons capacity on the same gantry and provide a beam for linking the two cranes together. This beam, with a 95-ton hook assembly, was designed to share the load proportionally between the two cranes.

When the contract for supplying and installing the 20-ton crane was placed with the Reed Crane and Hoist Company, Ltd., it was faced with a number of problems. The heaviest load to be lifted was approaching 7 tons and there was no possibility of using a supplementary derrick or mobile crane for the work. Further, the roof of the turbine house was of complex design, tarmac finished on the outside and with an immaculate, smooth plastered and moulded ceiling inside. To have introduced a strong point into this roof would have caused very considerable damage at excessively high costs, and would certainly and rightly have been rejected by the Central Electricity Authority engineers. It might have been possible to suspend sheave wheels through the ventilation louvres in the roof, but this possibility was over-ruled by the Central Electricity Authority because of the excessive loads which would have been applied to the adjacent portal frame. The use of an erection mast was next considered but the building was devoid of anchorages suitable for a mast of the weight and height necessary. Such anchorages could only be provided at the cost of very considerable damage to the tiled floor and walls and by welding heavy lugs to the crane gantry. Furthermore, the mast itself could not be raised in one piece because of space restrictions, so this means was rejected.

It was concluded that there was no conventional method of erecting the 20-ton crane and therefore consideration was given to less obvious methods. One factor of particular importance in deciding upon a method was that, whilst loads of up to 80 tons could be lifted to within 8ft of the gantry level with the existing crane, there was no straightforward method of raising any substantial load above this point. The complete absence of suitable anchorages at ground level for a winch and its associated deflector sheaves was a further difficulty.

It was decided that a lifting point, close to the roof, could best be achieved by constructing a latticed jib, with its base secured to the chassis of the 80-ton crane crab, and with its head extending 13ft beyond the hand rail of the 80-ton crane bridge to provide working clearance for the erection of the 20-ton bridge. Calculations showed that the jib would weigh approximately 1¼ tons. Because of the difficulty of raising so awkward a load above the 60ft level, this jib was designed for easy transfer to the 80-ton bridge in small sections. It was built in the form of two identical side panels, 3ft apart, each standing astride the 80-ton crab, with the feet resting on the crab side members. Each foot was located between two plates clamped to the crab side members and secured with a hinge pin.

Each panel was assembled in the horizontal plane so that use could be made of the gantry catwalk when assembling the heaviest and longest booms. As each panel was completed, it was hoisted into the vertical plane and, when both were in position, the cross bracing was added. The form of construction and the method of hinging the feet can be seen in the accompanying photograph which shows the jib after assembly on the 80-ton crab.



Erection jib for supplementary 20-ton crane fitted to the existing 80-ton crane

It was calculated that it would be necessary to suspend at least 10 tons of ballast from the 80-ton crab against the overturning moment of the loaded erection jib. It was arranged that this ballast should be increased to 15 tons suspended from the 80-ton hook, all of which would eventually form part of the test load for the new crane. This load could be raised and lowered through a distance of approximately 37ft without affecting its ballasting function. Using this load and by the introduction of a simple system of reeving, a 7-ton load could be lowered and raised from the jib head through 74ft. Thus, sufficient power and sufficient lift was provided for the erection of heavy components without the use of a winch.

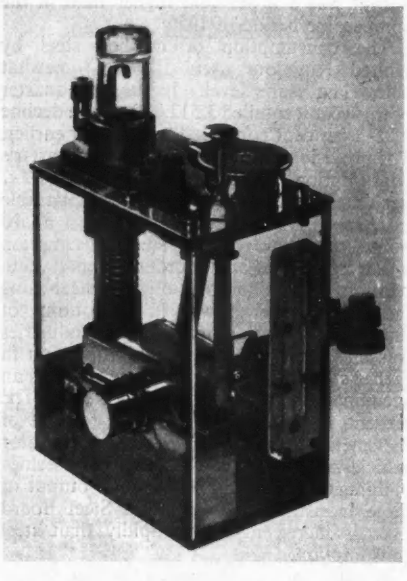
The new crane could not be lifted bodily because of its weight, but what was more serious, the end carriages could not be lifted separately, since the full travel of the erection jib on the 80-ton crab was too short to place any load directly over the gantry rails. However, the weight of the lighter bridge beam, that is the one without a walkway, plus the two end carriages, was a little below the maximum permitted load of 7 tons. To obtain a balanced load, temporary bolt holes for the lighter beam were arranged about the centre of each end carriage and the whole lifted together. A lifting programme was arranged which had the virtue of maintaining complete control over the position and security of the end carriages at all stages without individual lifting points, or chocking or lashing.

The final problem of installing the main bridge beams which were longer than the width of the gap between the gantry rails was overcome by raising the beam tilted at a slight angle. When the highest end had cleared the gantry on one side of the building, the beam was moved transversely until the lower end cleared the gantry on the other side. There was then just sufficient headroom to raise the beam until its lower end was clear of the gantry rail. The beam was then moved to its central position in respect to the gantry and lowered on to the rails. Particularly careful manœuvring was entailed in these operations as there was only a matter of inches clearance available at each end of the beam for endwise movement and between its upper end and the roof. As a matter of interest, it should be recorded that the whole of this work was carried out by a gang of five men in three working days, without any structural damage to the turbine house or its equipment.

Mechanical Lubricator

A MECHANICAL lubricator made by the British Manzel Oil Pump Company, Ltd., Durranhill Engineering Works, Carlisle, is suitable for handling oils and emulsified and detergent lubricants, and operates against working pressures of up to some 6000 lb per square inch. These lubricators are assembled in multiple units and the photograph we reproduce shows a single unit demonstration lubricator with a transparent reservoir.

The flow of lubricant can be seen through a drip tube in a sight chamber, and the flow is imparted by a vacuum created in the chamber on the initial part of each suction stroke of the reciprocating pump below. The oil drawn out of the drip tube flows down to an inlet port set about midway down the height of the pump cylinder. On the discharge stroke the plunger first seals this port and then forces the oil through two non-return ball valves into the delivery pipe leading to the point to be lubricated. The delivery stroke of the pump is actuated mechanically through a rocker arm, and the piston is spring loaded to effect the suction return stroke.



Drip feed mechanical lubricator for delivering oil at up to 6000 lb per square inch

The construction is such that any leakage of oil round the plunger as a result of wear will cause the oil to flow to the point of lowest pressure, which is the sight chamber. Any leakage is therefore immediately apparent from the reduction of the rate of flow from the drip tube. The lubricators are available for up to thirty feeds and in three pressure ranges up to 500 lb, 1500 lb and 6000 lb per square inch. For servicing purposes any pumping element can be easily withdrawn and replaced without need for stopping a machine or any other unit in a multiple lubricator assembly.

Industrial and Labour Notes

Railway Wages

At the end of last week the executive of the National Union of Railwaymen formally submitted to the British Transport Commission a new claim for a "substantial increase" in wages. The claim has been put forward on behalf of N.U.R. members employed on British Railways; it has been stated that a similar claim is to be made on behalf of London's underground railway workers. It will be recalled that the N.U.R. and the two other railway unions have already put forward claims for a shorter working week. Two of the unions, the N.U.R. and the Associated Society of Locomotive Engineers and Firemen are asking that the basic working week shall be reduced from forty-four to forty hours. Talks on these demands have not yet taken place.

Iron and Steel

The Iron and Steel Board has stated that, over the first eight months of this year, Britain's steel output averaged 412,800 tons a week, and was thus 6·2 per cent higher than in the corresponding period of last year. In August, a month always affected by annual holidays, steel output averaged 373,400 tons a week, compared with 340,600 tons a week in August, 1956. Pig iron production during August was at a weekly rate of 272,500 tons; in the first eight months of this year pig iron output was 8·4 per cent higher than in the comparable period of 1956.

The consumption of finished steel by United Kingdom users is still somewhat below last year's level. In the first quarter of this year it totalled 3,512,000 tons, a decline of 2·5 per cent compared with a year earlier. The provisional figure for the second quarter's consumption is 3,439,000 tons, which is 2·7 per cent below the figure for the comparable quarter of 1956. The Iron and Steel Board points out, however, that steel consumption a year ago was at an abnormally high level in relation to the output of the steel-using industries. The growth in the output of finished goods by a number of these industries was checked a year ago, but production in earlier stages continued, so that there was an accumulation of work in progress. The present situation is the reverse; output of the metal-using industries, notably motor vehicles, railway construction and shipbuilding, is expanding. The total output of these industries, the Iron and Steel Board says, is increasing more rapidly than steel consumption.

It must not be overlooked that the higher steel production, combined with the lower consumption of steel in the United Kingdom and the slower rate of stock building, continues to yield substantial increases in net steel exports. Last year, net exports* of steel totalled 978,000 tons; in the first six months of this year they amounted to 1,100,000 tons.

British Contractors Overseas

The Ministry of Works has lately taken to compiling statistics about the activities of British civil engineering and building contractors in overseas countries, and figures for the twelve months which ended on March 31, 1957, have now been published. Nearly sixty firms were working overseas, in more than fifty countries; they carried out work valued at £94,000,000 during the year, an increase of £7,000,000 over the previous year, but probably an increase of 4 or 5 per cent could be allowed to cover increases in costs relative to the previous year. The only comparable figure for other countries is that of £250 million quoted for work done overseas by American firms in the same period; Germany and Italy, however, are also keen competitors.

Although the work done by British contractors showed an increase, prospects for the present year are not so encouraging, since the value of new contracts obtained in the year under review was £92,000,000, a decrease of £17,000,000 on the previous year, and the value of work outstanding at the end of the year was £104 million, as against £115 million twelve months previously. The Ministry considers that troubles in the Middle East are a principal cause of these reductions.

Most of this overseas work is in the sterling area, but an appreciable proportion is in dollar countries. The dollar-earning contracts show signs of increasing, because contracts worth £29,000,000 were obtained in Canada during the year. According to Canadian statistics, Canadian annual expenditure on work of this kind is running at almost 350 dollars per head of the population, corresponding figures for the U.S., Great Britain and Australia being 280 dollars, £30, and £A38 respectively.

* Excess of steel exports over imports.

Overseas Trade

Exports of United Kingdom goods and manufactures in August were valued at £269,400,000. This was £12,000,000 below the July figure, but it will be realised that August exports are usually affected by holidays. When July and August are considered together, exports were 1½ per cent below the monthly average for the first half of this year, but 7 per cent above the figure recorded for July and August last year. Imports in August were valued at £335,600,000. Taking the July and August figures together, imports were just a little below the monthly average for the first half of the year, but 7½ per cent higher than in July and August, 1956. The visible trade deficit at the end of August was £55,700,000. The average deficit for July and August, £62,200,000, was £5,000,000 more than the monthly rate in the first half-year and £8,000,000 more than in July-August last year.

The Coal Board's Summer School

The theme of the National Coal Board's eleventh annual summer school, which was held at Oxford last week, was "The Colliery Management Team." One of the lectures was given by Mr. E. H. Browne, chairman of the West Midlands division, whose subject was "The Development of Colliery Management." He said many people believed that the same degree of interest in organisation which had been taken in the National Coal Board's "hierarchies" ought to be focused on organisation at the point of production, the colliery; and that, although it was clearly desirable to find the best system of higher control in the industry, it was of paramount importance to secure the best organisation at the colliery itself since this was the basic unit of the industry. Mr. Browne added that not much had been done to remould the pattern of colliery management and there was little real change going on at present. Interest and action must be stimulated and the process of reorganisation which was widely needed must be speeded up.

Mr. Browne went on the examine in some detail the functions of the officials directly responsible to the colliery manager, and suggested that these officials should be reasonably few in number, normally comprising a deputy manager or assistant manager, one or more under-managers, a surface foreman, a labour officer, an engineer and an administrative officer. He argued the case for the appointment of a chief colliery engineer, who would control the mechanical, electrical and civil engineering services below and above ground, and also referred to the pattern of supervision below the undermanager. Mr. Browne suggested that modern conditions justified the appointment of "functional foremen," each of whom would be responsible not for a part of the colliery, but for a particular operation or service.

Another of the lectures was by Mr. C. A. Roberts, secretary of the National Coal Board. He discussed the Board's organisation and general management policy. In his lecture, Mr. Roberts said he did not believe that the increase in the Board's staff would continue generally, though it might do so in particular directions, in the field of engineering, for example, for some time yet. Generally, Mr. Roberts remarked, the main structure of the Coal Board's organisation had stood the test of ten strenuous years and was well adapted to its task; his great hope was that the structure of the organisation would remain unchanged for a period of years. Mr. Roberts ended his lecture by saying that he looked forward to an increase in effective delegation, a decreasing need for headquarters and divisions to supervise in detail, and an ever stronger sense of spontaneous discipline on the part of divisions and areas. This would be helped, he claimed, by development in the use of modern techniques of management.

Prices of Materials

The Board of Trade has stated that the basic materials price index fell in August by 0·4 per cent, and that at the end of the month it was 4·6 per cent below the peak reached at the close of last year as a result of the Suez crisis. The index (June 30, 1949=100) takes account of basic materials (excluding fuel) used in "non-food" manufacturing industry; at the end of August it stood at 154·2. The fall, it is explained, reflected lower prices for copper, raw rubber, tin ingots and home-grown hardwood. Among the commodities which rose in price were home-produced steel scrap, linseed oil, coal for carbonising and lead.

The index numbers for materials used in the mechanical engineering and electrical machinery industries rose by 3·9 per cent and 2·6 per cent respectively. The increase in both instances resulted primarily from higher prices for iron and steel. It was offset to some extent, however, by decreases in the prices of various non-ferrous items, including brass ingots, brass strip or sheet, brass tubes and copper sheet. Prices of building and civil engineering materials rose by 1 per cent in August, mainly as a result of increases in the prices of iron and steel, roofing tiles, certain kinds of bricks, asbestos cement products, cast stone and cast concrete products, and a few other items.

Bethulie Bridge and Water Supply for the Cape Eastern Main Line

BY OUR SOUTH AFRICAN CORRESPONDENT

AS described in the March issue of the *South African Railway News*, two large projects were brought into commission recently by the South Africa Railways on the Cape Eastern Main Line. A new bridge to replace the old one over the Orange River at Bethulie, between Bloemfontein and Queenstown on the main line to East London was opened to traffic in March last, and a new plant to provide water for locomotives has been installed at Bethulie. The cost of the two projects, including the deviation of 3½ miles of railway track to connect the new bridge with the main line, will amount to about £338,000.

Bethulie Bridge.—The old Bethulie Bridge, built in 1890, was blown up during the 1899–1902 war but was rebuilt again while the war was still on. It carried 81 lb track, but the bridge became too light for the heavier class of locomotive and other rolling stock now used by the South African Railways, and speed restrictions over the bridge had to be applied. The new bridge (Fig. 1), 1150ft long with sixteen 68ft reinforced concrete deck spans, was built under private contract by the Roberts Construction Company. It is sited very near to the old bridge. Average height from stream bed to rail level is 50ft and all the piers are founded on rock, while the two abutments are carried by concrete piles, which are taken down to solid rock. To provide for expansion and contraction due to temperature changes, every second pier is split down the centre through the top 15ft. The split is 1in wide and this allows a certain amount of bend in the top half of the piers.

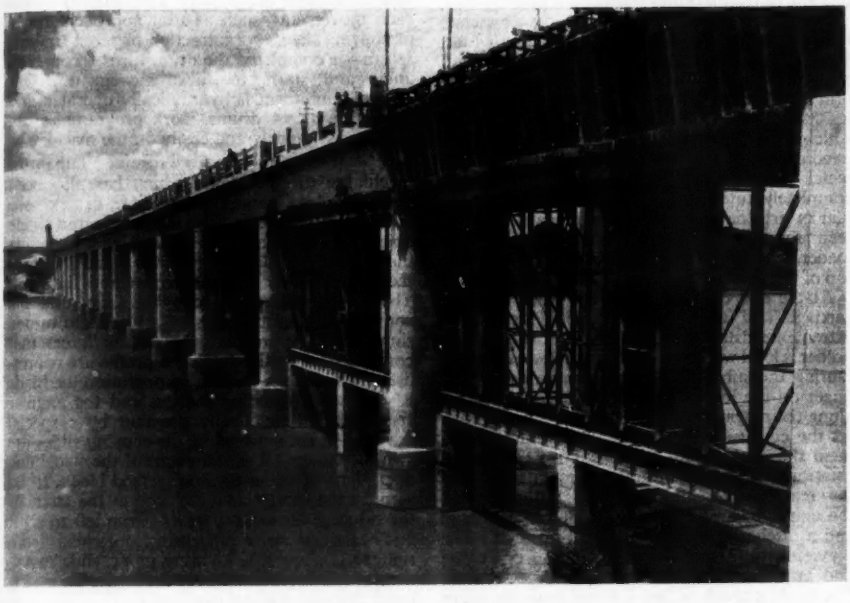


Fig. 1—A close-up view showing falsework supporting line shuttering for a span on the new Bethulie Bridge over the Orange River

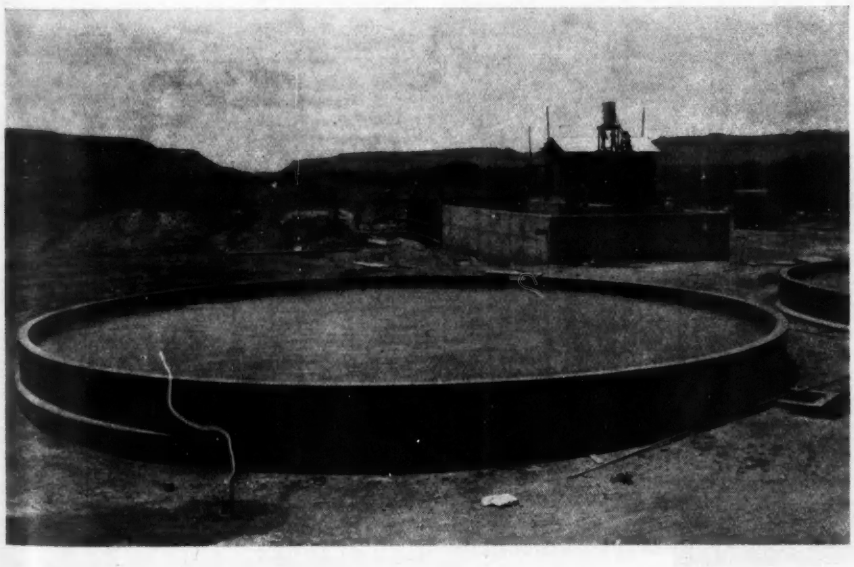


Fig. 2—Part of the new watering plant for locomotives near Bethulie. The 100,000 gallon reservoirs can be seen in the foreground, while in the background are the dosing house and sedimentation basin under construction

Water Supply.—With the construction of a new water plant (Fig. 2) on the north bank of the Orange River, to replace the old plant which was situated at Holmgrove, an interloop about 2 miles from Bethulie Station, the water problems on this section have been solved. The normal muddiness of the Orange River proved to be beyond the filtration capacity of the old plant, nor was it possible, during the low-flow periods of the river, to get the water to the pump intakes.

The main features of the new plant are of some interest. During dry periods the Orange River flows in channels in the river bed. When the new bridge was built, a curtain or cut-off wall was built down to rock between the bridge piers. At one span, however, near the north bank, the height of the wall was reduced by 3ft, to form a notched weir for low flows. The pump suctions were then placed at this point and even during exceptional droughts when the visible river flow appears to be zero, the seepage flow in the sandy river bed will be sufficient to maintain the train services.

Two low-lift pumps deliver the water into a presettlement unit of special design, developed by the South African Railways, into which the heavier silt portion of the water is dropped. The unit is flushed out periodically, disposing of about 20 to 25 tons of silt per day when the river is in flood. After going through the filtration plant, the clear water is pumped to two 100,000 gallon storage reservoirs located on high ground above Bethulie Station. From this point water is gravitated to 20,000 gallon pressed steel tanks, which feed the water columns where the locomotives are watered.

African Engineering News

South African Steel Production on the Increase

By expanding the capacity of the existing Pretoria and Vanderbijlpark works, the South African Iron and Steel Industrial Corporation (ISCOR) is to spend about £33 million to increase its production by about 33 per cent. A production rate of 2,000,000 tons of ingots per annum is envisaged, which will still leave South Africa dependent on a proportion of steel supplies from overseas. Production during the 1955–56 financial year amounted to 1,465,000 tons of ingots. South African steel is of fine quality by any international standards and is also reputed to be the cheapest in the world. The necessary raw materials are all available in the country, including huge reserves of high-grade ore, although there is a limit to the reserves of coking coal, a problem which is engaging the active attention of the South African Fuel Research Institute.

Early next year the erection should be completed at Iscor Works, Pretoria, of South Africa's largest blast furnace, the fourth of its kind there. This will have a hearth diameter of 25ft. At Vanderbijlpark the Corporation's largest furnaces have each a hearth diameter of 21ft 6in. When this fourth blast furnace at Iscor Works, Pretoria, is blown in, the iron-making capacity there will be increased from about 630,000 tons per annum to more than 1,000,000 tons per annum. This extra iron will be used to increase steel production and to assist in providing for the ever-increasing demands for foundry pig iron.

Steel Ship Construction at Cape Town

A steel ship which is to be a fisheries research vessel, costing £110,000, is being built in a shipbuilding yard in Table Bay harbour. A Cape Town engineering firm obtained the contract from the Fisheries Development Corporation and the vessel is to be used for the Division of Fisheries. This new research ship will be 120ft long and will have a laboratory for seagoing scientists. It will also be equipped with radar, echo-sounder and various useful aids. South African material is being used in the construction of the vessel, the design of which was evolved in collaboration with a British shipyard.

European Machine Tool Exhibition

No. 1

THE fifth European Machine Tool Exhibition sponsored by the European Committee of Machine Tool Industries (and organised by the Verein Deutscher Werkzeugmaschinen Fabriken) was opened at Hanover on September 15 and will continue until September 24. At this exhibition the principal products of 995 firms from the major machine tool manufacturing countries of Western Europe are being shown, as compared with the 863 firms which were represented at the fourth exhibition held in Milan three years ago. As at the previous exhibition, the largest representation is of German manufacturers, with the products of some 650 firms, compared with 298 at Milan. The exhibitors from other countries and the comparative figures for the last exhibition are as follows: Britain 44 (44); France 42 (80); Italy 65 (241); Switzerland 86 (74); Belgium 18 (25); Sweden 18 (19); Austria 19 (13); and the Netherlands 13 (nil). The stands of the fifth exhibition cover about 54,000 square metres.

The excellent facilities available at Hanover, which impose no restrictions on the weight or size of the machines, have been used to full advantage to show some particularly large machines in operation. Ample accommodation is provided in eleven large halls for what is probably the largest collection of machine tools ever shown in Europe. Each hall, or a group of halls, is generally devoted to showing one or two classes of machine tools, a majority of which are engaged on typical production work. In Hall 1 there are shown most of the very heavy machines, including planers, shapers, gear cutters, broachers and large lathes. Three halls (Nos. 2, 3 and 5) are concerned with lathes, capstans, turrets and automatics and their ancillary equipment. Hall 4 is used for exhibiting milling machines, sawing and filing machines, and an interesting series of special purpose machines. Production grinding machines are shown in one of the No. 8 group of halls, and other parts of this group house boring mills and what are generally termed metal forming machines. Hall 7 is used to exhibit tool and workshop grinding machines, power tools, welding equipment, heat treatment plant and die casting machines. The precision tools, measuring and testing equipment, are in Hall 9.

The use of automatic work cycles, automatic feeding and unloading and pre-selection of work programmes shows a steady increase on many machines concerned primarily with batch production, to reduce the need for skill on the part of the operator and need for attention other than loading of blanks and removal of finished parts. Where previously such equipment has often been an accessory fitted as required, it now forms part of the actual design on many of the machines shown and it gives the added advantage of integral operation and rigidity of construction. In this direction some of the lathes, automatics and gear cutting machines, are of particular interest. A large number of special purpose machines making full use of unit heads are shown in operation, as well as some interesting transfer line equipment. At an exhibition of this size, the potential buyer has a difficult task indeed in choosing plant from the very large selection available, but the facilities with so many machines in operation give an excellent opportunity for studying the particular points in similar adjoining equipments, which cannot readily be obtained other than at such an all-embracing international exhibition. The number of machines exhibited is such that, with the limited amount of space at our disposal, it is not possible to give more than a general impression of the trend of development with notes on the interesting points in design of some of the machines shown.

Some particularly interesting developments have been made by George Fischer, Ltd., Schaffhausen, Switzerland, in connection with automatic loading and unloading devices for the firm's well-known copying lathes. One of the KDM-7/50 machines fitted with such a device, which is illustrated in Fig. 1, is designed to handle components from 0·4in to 3·5in diameter and from 2·75in to 17·7in long on a completely automatic cycle. In this machine the blanks are loaded in the tray magazine, to be seen above the headstock, and the automatic loader is carried on the horizontal slide along the top of the machine.

At the end of a turning cycle, when the feed carriage and the template holder are at the extreme headstock end, the cradle of the loading holder is level with the next blank in the magazine. During the subsequent return movement a feed finger on the loading assembly pushes the blank along the magazine and on to the loading cradle. At the conclusion of the carriage return movement the workpiece is located above the axis of rotation. In the meantime, the main spindle of the machine has been stopped automatically, the chuck opened, the tailstock barrel retracted and a discharge chute swung into position. The previously turned workpiece falls into this chute and gravitates on to a conveyor or container. The loading cradle is then lowered until the blank is positioned precisely between the centres, and the tailstock barrel then advances to hold it between the centres when the chuck closes, and the spindle starts. As the holder cradle then rises ready for the next loading cycle, its cradle bracket opens to slip from under the blank. The machining cycle then restarts and this work cycle is repeated as long as a supply of blanks is maintained in the magazine.

A special automatic copying machine on the stand is for turning ring-shaped components, particularly ball bearing races. On this machine the copying slide can be set on the feed carriage at angles of 60 deg., 90 deg. and 120 deg. to the axis of rotation to enable the machine to be adapted rapidly for the profiles that are to be copied. The 60 deg. and 120 deg. positions are used for the external and internal copying of perpendicular shoulders, and the 90 deg. position is used for spherical shapes. With a duplex tool-holder or double-tool boring bar, it is possible in one chucking to make two cuts in opposite directions to machine shoulders that are set facing each other.

An automatic swivelling template-holder enables two successive cuts to be made from two differently-profiled templates, without having to set up the machine again for the second cut. The machine is also fitted with an automatic work cycle programme equipment which uses an interchangeable sequence drum with inserted control pins to control the selected movements. When each movement—such as tool approach, travel of copying slide, tool retraction or rapid traverse return—is completed the drum turns through an angle and starts the next movement. This control equipment is hydraulically operated and by storing preset drums, work programmes can be changed quickly and easily on the machine.

A "two-swing" copy turning lathe for machining turbine blades which has also been developed by George Fischer, Ltd., can be seen in Fig. 2. On this lathe it is possible in a single operation to machine the entire blade, including the convex and concave sides, the blends between the blade profile and the crown and the root. The machine uses two copying slides and the convex and concave sides of a blade are turned simultaneously so that the cutting forces that come to bear vertically on the profile are neutralised. During the machining operation the blade is given an oscillating motion and the angular speed is kept practically constant by a special device. In the illustration, the copying slides are swivelled to the left as at the start of the machining operation. During turning, a feed block, to be seen on the shaft below the slide at the front of the machine illustrated, travels from left to right and at the same time the cutting tool swings from right to left round a pivoting point, slide movements to impart the required profile being made through a tracer equipment.

A large number of lathes are shown by the V.D.F. group of manufacturers—which consists of Gebr. Boehringer G.m.b.H., Goppingen;

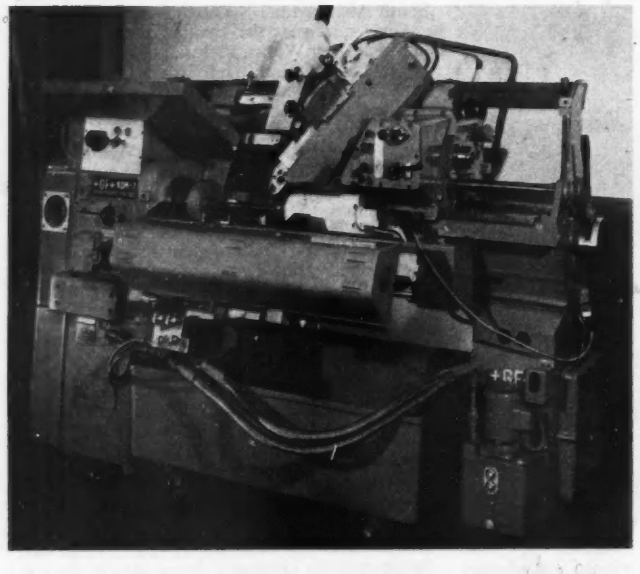


Fig. 1—Automatic-cycle copying lathe equipped for automatic loading of blanks and discharge of finished work—Fischer

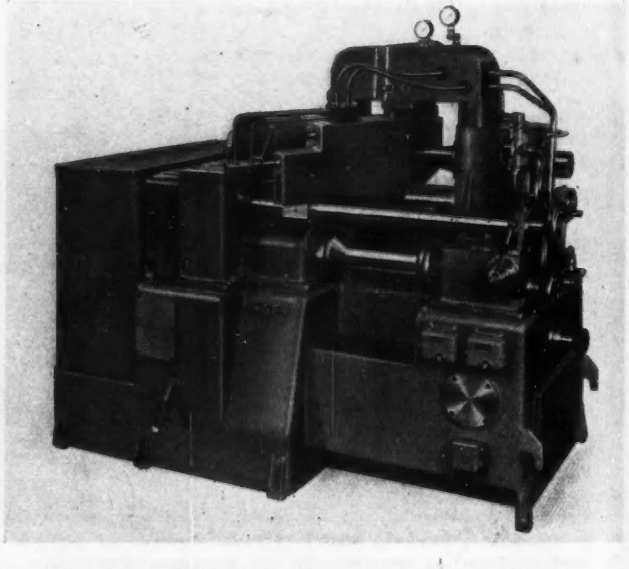
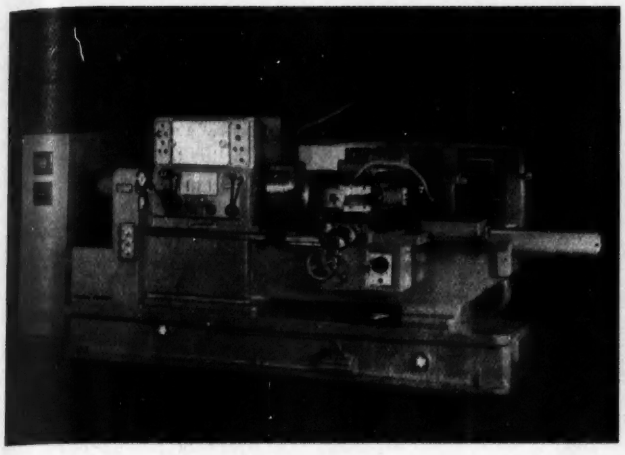
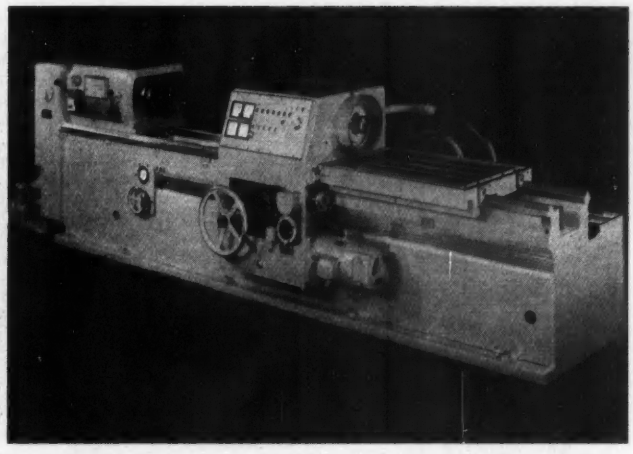


Fig. 2—Copying lathe for turning turbine blades in a single operation—Fischer





Figs. 3 & 4—(Left) "Unicop" copying lathe with indexing three-way toolpost and template holder—V.D.F. (Right) Deep hole boring lathe with central chip removal equipment—V.D.F.

Heidenreich and Harbeck, Hamburg; and H. Wohlenberg K.G., of Hanover—and is represented in this country by the Sykes Machine Tool Company, Ltd., Staines. A new lathe in this group has a centre height of 29½in and a maximum turning length of 236in. It is built with triple bed ways so that the carriages can travel past the steadies and tailstock when machining long components. The makers state that components weighing up to 16 tons can be accommodated without additional support on the machine. Twenty-four spindle speeds from 0·9 to 180 r.p.m. are available with a stepless range of feeds from 0·012in to 28in per minute.

One of the two new "Unicop" copying lathes shown by V.D.F. is illustrated in Fig. 3 on this page. These machines are equipped with an automatically indexing three-way toolpost and a corresponding three-way swivelling template holder to make them combined turret and copy turning lathes. The automatic work cycle includes preset speed and feed changing. One of the machines, with a 10in centre height, is shown copy turning a brake cover in which four tools are used for rough turning of one side and the subsequent form copying of each profile. Two "Polycop" machines are also fitted with the same automatic indexing three-way toolposts and template attachments.

A "DKM II" double copying lathe also on the V.D.F. stand is intended for the production of rolls, axles and similar components suitable for central clamping. It has two slides, one on each side of the headstock. These slides are synchronised and both ends of the component are machined simultaneously. A deep hole boring lathe, which is shown in Fig. 4, is designed for central chip removal instead of the conventional central coolant delivery and side chip removal. This is claimed to increase cutting capacity and improve surface finish of the work. On this machine the work is gripped in the spindle chuck and a coolant delivery unit is housed in the carriage, which is stationary during the boring operation. The carriage is pressed against the face of the workpiece to form a seal against the coolant flow and serve as a guide to the tool as it enters the work. The flow of coolant between the boring bar and the bore of the work flushes the chips into a bore through the bar. A container on the boring slide collects the swarf as the coolant passes on through to a filter before being recirculated. To ensure efficient swarf removal when boring deep holes a coolant installation is capable of delivering 132 gallons per minute at a pressure of 294 lb per square inch. This delivery is, however, only required for relatively large bores and for smaller work less coolant is used at the higher pressure of 735 lb per square inch. Three pumps are provided, delivering 19, 30 and 83 gallons per minute respectively; each may operate independently or the three can work together.

Bores up to approximately 2⅜in diameter may be produced from solid material, and this can be increased to 6in by boring and trepanning. The slide to which the boring tool is fitted is equipped with an instrument panel from which all the functions of the machine can be controlled. The machine has a spindle speed range from 140 to 1800 r.p.m. in twelve steps and its feed range is from 0·0001in to 0·313in per revolution.

A Boehringer automatic crankshaft lathe can be used for machining the centre journals, web section and end pins of four-throw crankshafts in one setting, using fifteen to twenty tools simultaneously with rough turning followed by finish turning..

A representative group of the automatics made by Wickman, Ltd., Coventry, includes one of the firm's 7¼in capacity six-spindle chucking machines tooled up for machining bearing housings on a twenty-five second production cycle, and equipped with an automatic work loading and unloading device. This device consists of a primary loading chute for holding about ten components and running along the left front of the machine, and having a secondary chute at right angles leading down to the tooling area. The component rolls down the primary chute into a swivelling holder, which allows it to fall into the secondary chute. This chute holds the component in position for a transfer arm, which picks it up and places it in the chuck, withdrawing when the chuck automatically closes. To unload a finished component the transfer arm again advances and carries the component to a third chute, whence it slides into a work tray. Another six-spindle automatic chucking machine of 6½in capacity has automatic loading and unloading of the component and a clutch pulley. By this method, assisted by the machine's modification to double indexing, the automatic unloading device at station 5 reverses the part-machined component and loads it at station 6 for the second phase of machining. Besides doing work which would normally require two machines the fully automatic nature of the machine ensures a constant cycle time of twenty-eight seconds without being subject to the delays imposed by hand loading.

An exhibit of Maschinenfabrik Deutschland A.G., Dortmund (Drummond-Asquith (Sales), Ltd., Birmingham, 2), is the headstock and faceplate of a heavy combined facing and centre lathe. This machine (Fig. 5) is of movable unit construction, consisting of the headstock, stand carriage, toolpost saddle on an independent bed, and a tailstock. These units can be arranged on a base plate in any required position to suit the size and shape of the work. The feed to the toolpost saddle is transmitted by an "electric shaft" consisting of a motor coupled to the main spindle of the headstock, and a feed motor at the saddle bed, the rotors of both being coupled electrically to ensure synchronous running. Changes in direction of feed are accomplished through electric clutches, which can be used to copy on full turning length by means of electrical tracer control.

A threading attachment is available for cutting threads on full turning length, longitudinal travel of the toolpost in this case being effected by a separate leadscrew and nut, the drive being taken from the existing "electric shaft."

This lathe is designed to take workpieces

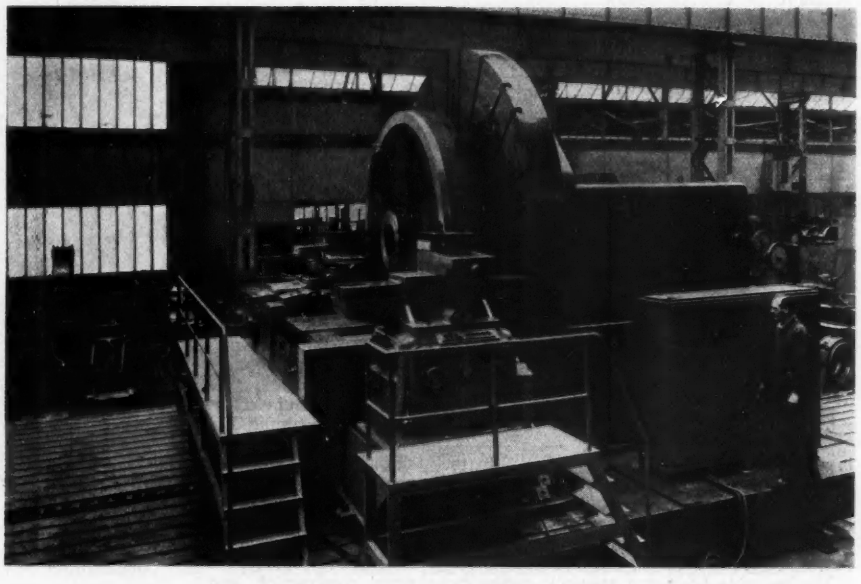


Fig. 5—Heavy-duty lathe of unit design with a bedplate on which the headstock, carriage, toolpost saddle and tailstock can be set in accordance with work size—Deutschland A.G.

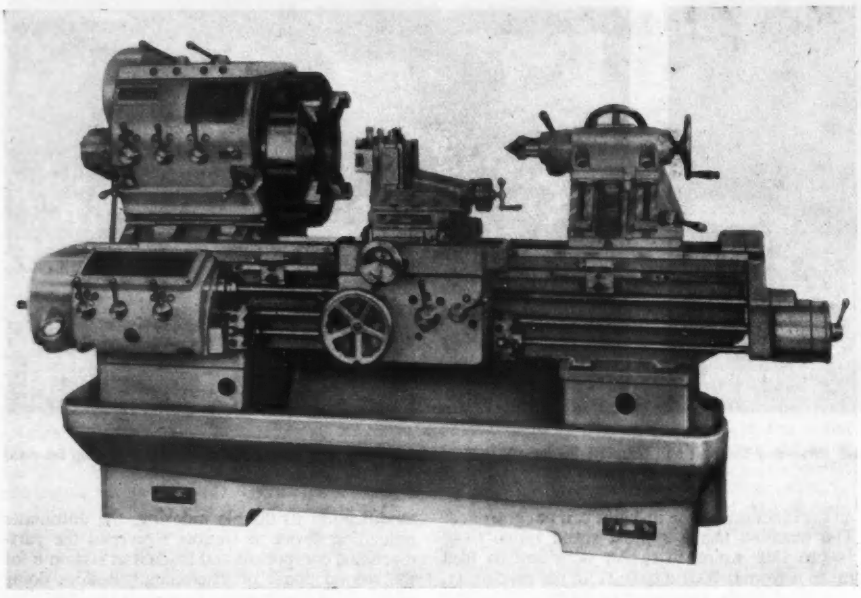


Fig. 6—" Neomat " centre lathe with adjustable headstock and tailstock—Heid

weighing up to 60 tons between centres and 16 tons freely suspended at the face-plate. Its face-plate diameter is 158in and centre height 87in: the maximum distance between centres of 158in can be increased if extra base plate length is added. The movable stand carriage or short traverse toolpost unit provided enables the facing lathe to be used in a more normal manner.

A combined universal and copying lathe, the " Neomat VK–56," which is being exhibited by Maschinenfabrik Heid A.G., Vienna I (Newman Industries, Ltd., Yate, Bristol), embodies some very striking design points. As our illustration (Fig. 6) shows, both the headstock and tailstock are mounted on inclined slides, enabling the centre height to be steplessly varied from 400mm to 560mm. By contrast with a lathe with a gap bed, the increased swing is available over the whole turning length. It is claimed that the arrangement allows the larger diameters to be machined without the toolpost overhanging the bed. The tool is therefore always in a favourable position for absorbing the cutting force. The up or down movement of the headstock is effected by an electric motor, while the tailstock

Fig. 7—Model " BO3 " boring machine—Safag

is adjusted by means of a handwheel. In the two limit positions alignment is ensured by fixed stops, while intermediate settings are obtained by means of vernier scales reading to 0·05mm, or, if a still greater accuracy is required, by means of a ground test bar and dial indicator.

The movable head and tailstock design can also be used for carrying out certain boring and milling operations, using a clamping table on the saddle in place of the compound slide rest.

Converting from normal use to copying, with the Heid direct electric tracer system, and back is done by means of a small lever. The copying system is an integral part of the lathe and, it is stated, does not involve the use of any complicated elements, relays or electronic valves. Copying is said to be economical even with small batches of three to five workpieces. The tracer unit controls both directions of feed so that the only limitation of the copying action is that imposed by the shape of the cutting tool. Four sheet metal templates can be mounted at the rear of the bed, at right angles to each other, so that by indexing the holder four different contours can be machined.

In the " Neomat " the bed ways are completely covered to protect them, and both the saddle and also the cross slide screw spindle move in oil baths. In our illustration there may also be seen the quick-change three-station toolpost, with screw adjustment of the height of the cutting tools. A separate rapid traverse motor is built into the apron to provide quick approach and return movement. Screw threads are rough-machined using the feed shaft and bed rack, thereby reserving the lead-screw for the finishing cut. Forward and reverse drive and braking of the headstock spindle is done by Heid electromagnetic multi-disc clutches. These have no sliprings and are self-compensating for wear.

The "Model BO3" boring mill (Fig. 7) made by the Safag S.A., Bienne, represents a novel construction with respect to the method of working. It has been specially built for the batch manufacture of workpieces which have to be machined with several tools. The mill has a hydraulically controlled horizontal table, the boring spindle being situated at a fixed height in the head. A d.c. motor, fed by a converter, provides a stepless spindle speed range.

The advance of the table is limited by ten adjustable stops fitted on a drum which can be indexed by a hand lever. A ten-pole switch coupled to this drum is connected to ten potentiometers. Each potentiometer allows a desired speed to be given to the spindle, so that each tool will work at its proper speed. The different tools are held in quick-change chucks, and can be changed without stopping the spindle stock. Advance and the return of the table are regulated by separate controls and controlled by a single combined lever. Pressure on this hand lever causes the table to move rapidly; when the lever is released, the table continues to move at the pre-speed. The right-hand position of the lever produces right-hand movement, and vice versa. Another device fitted at the drum gives a rapid approach motion of the table, followed by the set feed just before the workpiece is contacted. Quick-clamping fixtures for holding the workpieces are fitted to the table by means of T-slots.

An exhibit of interest amongst the plant exhibited by gear cutting machine manufacturers is a transfer line of cluster gear cutting machines made by Churchill Gear Machines, Ltd., similar to those described in our issue of February 8 last. An automatic cycle magazine-fed gear cutting machine shown by a British maker is the new " Sykomatic " generator of W. E. Sykes, Ltd., which is illustrated in Fig. 8. The rotary turret of this machine holds twelve automobile layshaft gears, and on a 3·2-minute cycle gives uninterrupted working operation for nearly forty minutes.

The base of the work fixture is bolted to the saddle of the machine, and a heavy vertical column supports the indexing magazine and a

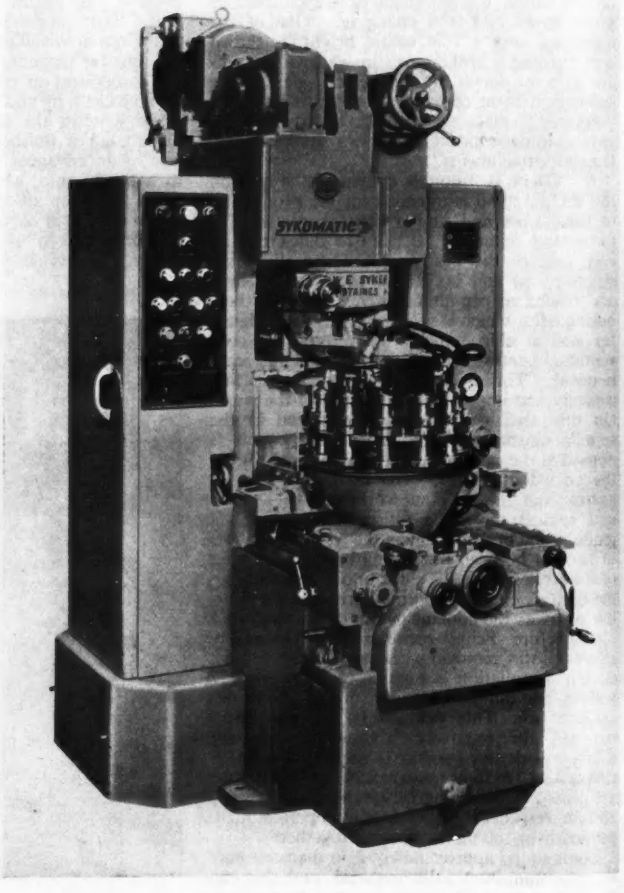


Fig. 8—Magazine loading, automatic cycle gear generator for automobile gears—Sykes

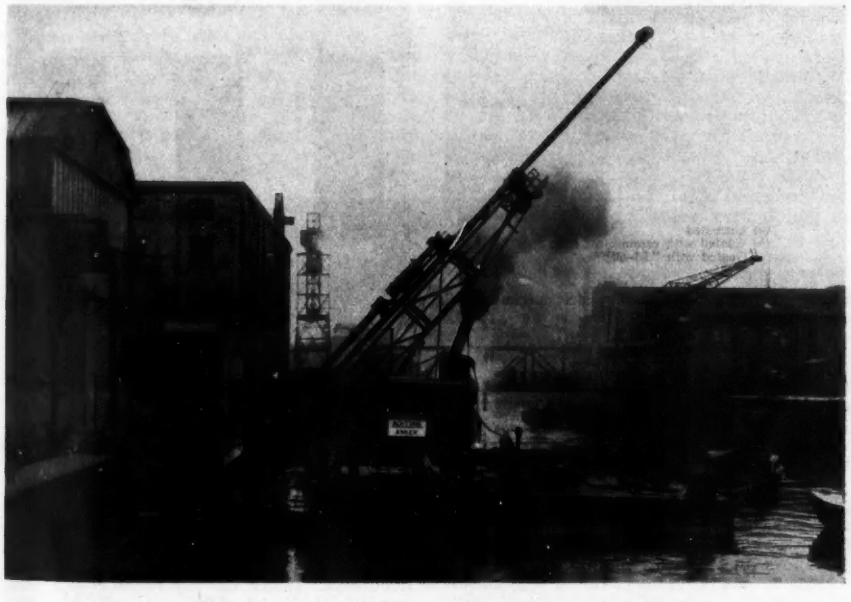
top plate. The top plate, which carries the tailstock and indexing piston, is fixed to the top of the column, both elements being supported by a slide bolted to the front of the machine. A hydraulic piston and a dead stop are provided to lock the fixture at the correct centre distance position.

The magazine is free to rotate and slide on the column, and a spur gear fixed to its upper part meshes with rack teeth cut in the indexing piston rod. The chuck is of the expanding mandrel type and is bolted to the worktable. With the magazine fully loaded, the index piston forward, magazine up and chuck released, the cycle start button is pressed. The tailstock moves down to enter the bore of the component, and its continued downward movement takes the magazine down and pushes the work on to the chuck. When the gear is hard against a locating face the chuck is operated by a sequence valve to clamp the work. The index piston then moves to the rear, the cutter and coolant motors start, the component is fed towards the cutter and the normal gear shaping operation then commences. During infeed of the saddle, oil at low pressure is applied to the clamp to give additional support to the fixture. When the gear is at the correct cutting depth, oil at high pressure is applied to the clamp and the fixture is locked for the final cut. After the gear has been cut the clamp is released, the saddle retracts and the cutter motor stops. The chuck is released and the tailstock and turret move up to lift the component clear of the chuck. The tailstock continues its upwards movement until it is clear of the work, when the index piston moves forward to bring the next component to the loading position, and the cycle restarts.

(To be continued)

Pile-Driving Plant

We have received details of the Model "MR 40" pile-driving plant, made by Menck and Hambrock G.m.b.H., Grosse Brunnenstrasse 78, Hamburg-Altona 1, German Federal Republic. The equipment, which is shown at work in the accompanying illustration, has a frame consisting of only three sections, which are held together by clamps. This, it is stated, makes for quickness of assembly and dismantling, and



Tubular frame pile driver at work driving sheet piles at 45 deg.

easy loading on road or rail transport. The frame is a tripod structure and requires only one spindle for tilting. By virtue of its tubular construction, the frame is very rigid, at the same time having minimum weight. During lifting and lowering no jamming or twisting can occur, it is stated.

All movements of the plant are power-controlled. The machinery is equipped with three drums, respectively for the hammer, leader and pile. As prime mover, a coal or oil-fired steam engine is used. The upper carriage can turn through 360 deg. For better manœuvrability, the leader and frame are separated from one another, the leader being held in a Cardan suspension in the frame head and guided at the bottom in a sliding bracket.

As the frame can be raked up to 1 : 1 to the rear, piles can be driven at up to 45 deg. to the vertical. The plant can be equipped with an undercarriage for running on rails, or built as a floating unit without undercarriage. Hammers are either semi-automatic or fully automatic double action, and are driven by steam or compressed air. Diesel hammers can also be employed. The double acting hammers can also be operated freely suspended from a crane rope or pulley block, in which case it must be guided by special leg guides. Double acting hammers can also be used as pile extractors or as rock chisels.

Pulse-Jet as Agricultural Spray

Since 1950, Société Nationale d'Etudes et de Constructions de Moteurs d'Aviation (SNECMA) has been engaged in the development of pulse-jets without moving components. These designs have no mechanical valves, which are stated to be a technical complication and a likely source of trouble. The first pulse-jet was the "Escopette," which for a weight of 4·8 kg developed 10 kg of static thrust, and was developed into the larger "Tromblon." A more recent design is the "Ecrevisse," in which the tube is bent through 180 deg., a fact which makes it possible to dispense with the recuperator, a component which had been used in the two designs mentioned for reversing the undesirable forward flow of the gases at the time of the explosion. Details have been released regarding the "Ecrevisse Type A," which has a weight of 6 kg, an overall length of 1540mm, and gives a maximum thrust of 20 kg, while "Type B" is 2480mm long, weighs 10 kg, and delivers up to 30 kg thrust for a fuel consumption of 1·35 kg/kg static thrust per hour. Larger versions of this design have been announced, with thrusts up to 150 kg. These include the "Pulsavia" pulse-jet of about 50 lb thrust, of which an interesting agricultural version has recently been developed and put on the market under licence, under the name "Agricolavia," by Pulsavia, 27, Rue Marignan, Paris (8e).

The equipment serves as a spray for insecticide in liquid or powder form. Its low weight, 120 kg with stand, renders it suitable for mounting on the back of a light open truck. The jet, which has a frequency of 50 c/s, is stated to have a range of 100m to 150m in still air, and of penetrating about 50m to 100m of dense frost. This last penetration is stated to be due to the pulsating nature of the jet, which is more effective than a steady jet of the same power (about 100 h.p.). Initial velocity is over 550m per second. While the combustion chamber temperature reaches 850 deg. Cent., necessitating the use of stainless steel, the jet temperature at the outlet is less than 100 deg. Cent., so that there is no danger to vegetation being set alight.

The installation comprises four principal components, i.e. the pulse-jet and stand, the fuel tank, and one or more containers with low-pressure feed (1 kg per square centimetre) for liquids which are to be sprayed. Powders may be sucked directly from the swills through a special nozzle. The fuel system is pressure fed at 2 kg per square centimetre by means of a constant flow injector. Electrical equipment comprises an automobile spark plug and vibrator 6V or 12V coil. This is only in use during starting, which is done by means of compressed air, obtained from a portable air compressor or from bottles.

The sprayed chemicals are in contact with temperatures of less than 100 deg. Cent., but only for about a millisecond. The chemicals undergo accelerations of the order of 200,000 *g*., which is sufficient to break them up into particles of 1 micron or larger, up to 100–150 microns, depending on the size of spray jets used. These jets are set in a revolving support to enable a quick changeover to be made to give 50, 80 or 120 microns diameter particles. With a change in the ambient temperature, adjustment of the droplet size enables a constant rate of spraying to be maintained. Oily phases may be sprayed at 50 to 70 hectares per hour or more, or 2000 trees 30ft to 45ft high per hour, at the rate of 3 to 9 litres per hectare (1 to 3 quarts per acre). Watery solutions can be sprayed at the rate of 100 litres (22 gallons) per minute. The spraying of a fine water jet is thought to be of particular interest for fighting forest or fuel fires. Powders can be sprayed at up to 2 tons per hour, corresponding to 18 kg to 27 kg per hectare (16 lb to 24 lb per acre). Fuel consumption is stated to be generally less than 3 litres per hectare (1 quart per acre).

International Congress of the Motor Industry

The Seventh International Technical Congress of the Federation Internationale des Sociétés d'Ingénieurs et de Techniciens de l'Automobile (F.I.S.I.T.A.) is to be held in Paris during the period May 19–28, 1958. The congress is being organised by the Société des Ingénieurs de l'Automobile, 5, Avenue de Friedland, Paris (8e). No general theme has been set, in order to give the widest scope to the lectures which are to deal with unpublished researches and development work. The number of lectures will be limited to twenty. Optional visits to the principal French factories of the automobile industry, as well as excursions, will take place from May 23 to May 28. Those interested should contact the Secretary, The Institute of the Motor Industry (Inc.), 40, Queen's Gate, London, S.W.7, in time for final registration to be received by November 30.

Free-Circulation Card for Community Workers

On September 1 began the issue by regional employment services of the countries of the European Coal and Steel Community of the new Labour Card, which enables the holder to work in any of the Community countries without the labour permit normally required by foreign workers. Twenty-nine trades in the coal industry and twenty-seven in the steel industry are covered by this measure. Workers in those trades are now able to accept offers by Community employers either directly or through the usual employment services. The issue of the Labour Card follows ratification on June 1 by Luxembourg, the last of the six countries to ratify, of the Convention on Free Circulation of Labour, proposed by the High Authority and approved by the Council of Ministers on December 8, 1954.

Approved Method of Applying Cermet Coatings

BY OUR AMERICAN EDITOR

A RAPID, economical process for applying a common cermet coating to a metal base is now in use at the National Bureau of Standards, Washington, D.C. In this case the cermet powder is a chromium-boron-nickel mixture that is combined with a ceramic frit. The process employs ordinary ceramic coating procedures to replace the former flame-spraying method and provides a hard, high temperature-resistant facing for metal parts. The coatings have been found to have excellent thermal shock resistance and are reasonably ductile. Cermets possess properties of both metals and ceramics. The chromium-boron-nickel mixtures have some degree of ductility, are resistant to thermal shock and oxidation at high temperatures, and retain their strength and hardness at high temperatures as well. In recent years, chromium-boron-nickel layers have been used extensively as hard facings for metal parts which are subjected to the severe conditions of erosion and oxidation. In one commonly used process, the chromium-boron-nickel powder is flame-sprayed on to the metal part. This overlay is then fused to the base metal with an oxy-acetylene torch. The resulting layer is dense and well-bonded but has several disadvantages. First, it tends to be expensive for large-scale production ; secondly, the flame-spray technique is unsuited to the coating of cylindrical parts of small inside diameter ; thirdly, the process is not feasible where thin layers of about 0·002in are required. To overcome these objections, the Bureau undertook a

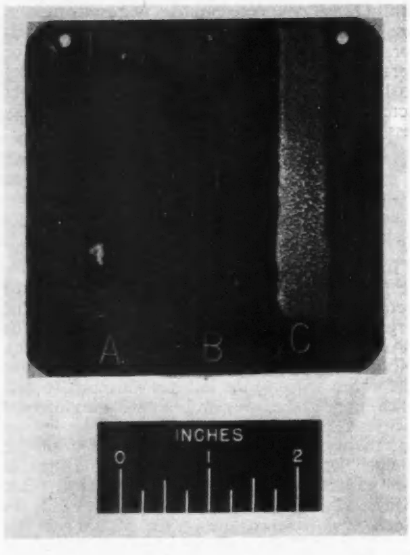
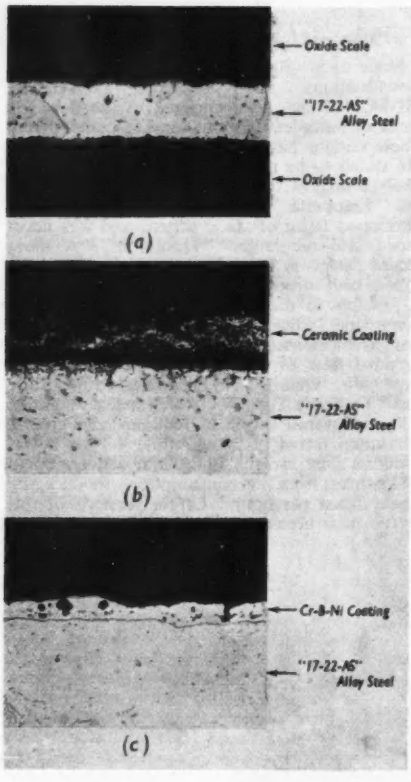


Fig. 1—Heat-resistant alloy specimens coated with chromium-boron-nickel cermets after firing in air at 1950 deg. Fah.

study of other methods of applying chromium-boron-nickel cermets. So far, the use of ordinary ceramic coating procedures appears to be the most successful.

In the N.B.S. process, a slip is prepared from a cermet powder and a ceramic frit. However, instead of flame-spraying the material, the usual ceramic coating procedure is followed and the slip is applied to the metal part at room temperature by either dipping or spraying. The part is then fired at a temperature above the melting point of both the cermet and the frit. During the firing the ceramic phase in the coating serves as a flux to permit the welding of the cermet particles without the necessity of a highly-purified, oxygen-free atmosphere. Depending on the firing temperature, the ceramic material either " sweats out " to the surface or remains as occlusions in the cermet network, while the cermet particles melt to form a continuous layer that becomes brazed to the surface of the base metal. In one series of experiments, coatings with different ratios of frit to cermet powder were prepared and applied to various base metals. It was discovered that the sweating out of the glassy phase to the surface of the cermet layer occurred at a firing temperature of 1900 deg. Fah. for coatings which contained five, ten, or twenty parts by weight of frit. However, a temperature of 2100 deg. Fah. was required before sweating



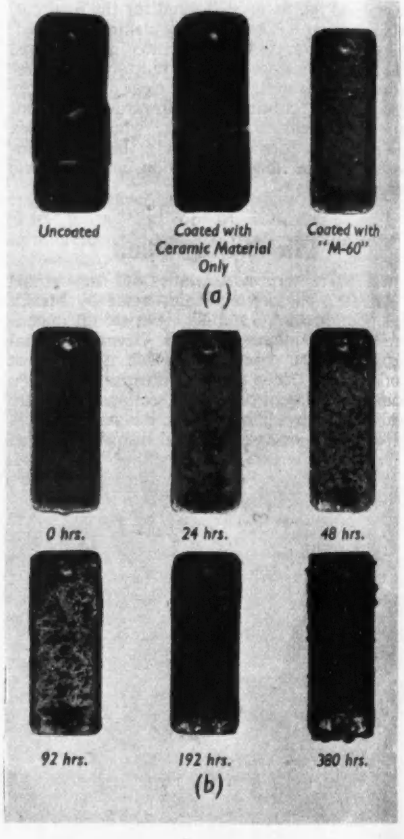
(*a*) Uncoated
(*b*) Coated with ceramic material only
(*c*) Coated with " M-60F "

Fig. 2—Micrographs of low-alloy steel specimens with and without coatings after firing in air at 1500 deg. Fah.

out occurred with a coating which contained fifty parts by weight of frit. In the cases where sweating out did not occur at all, the glassy phase was found to be enmeshed in a welded network of the cermet material.

Firing time had little effect on the appearance of the coatings ; a coating appeared the same after sixteen minutes of firing as it did after two minutes. Firing in air gave satisfactory coatings on alloys that initially had good oxidation resistance, but a furnace atmosphere of low oxygen content was necessary to achieve satisfactory protection on such metals as molybdenum, ingot iron, and several low-alloy steels. Neither thorough cleaning nor roughening of the metal surface prior to applying the coating was essential. Satisfactory coatings were obtained on smooth surfaces which had been only mildly degreased before applying the slip. The coating with the best continuity of the Cr-B-Ni layer and with the best appearance was obtained from a mixture of ten parts of frit, ninety parts of cermet powder, and five parts of clay by weight. This coating was designated " M-60." With this mixture, coating thicknesses in the range of 0·004in to 0·008in can be achieved by single-coat application. For thicknesses greater than this range, multiple coatings are recommended. For thinner coatings, a finer grinding of the slip is required. Such thin compositions have been designated " M-60F."

With the coarsely ground coating " M-60," the glassy phase forms at the surface of the cermet as small beads when fired according to the recommended procedure. These beads tend to flake off on cooling, but light sandblasting or treating in molten alkali will result in a specimen of more acceptable appearance. On the other hand, when the finely-ground coating, " M-60F " is used, and application thicknesses are less than 0·003in, the glassy phase, which comes to the surface, forms a uniform glaze that adheres to the underlying cermet layer. In this case, the specimen appears to be ceramic-coated. The possible use of the " M-60F " coating for protecting low-alloy steels against oxidation at 1500 deg. Fah. was also investigated. Uncoated specimens scaled rapidly, whereas the " M-60F " coating



(*a*) Heated for 24hrs at 1800 deg. Fah.
(*b*) Specimens coated with " M-60 " heated for varying times at 18,000 deg. Fah.

Fig. 3—Ingot iron specimens with and without coatings after firing in air at 1800 deg. Fah.

prevented any loss in effective thickness for the maximum test period of 800 hours. However, spectrochemical analysis has shown that boron diffuses into the alloy structure during the heat treatments. In one test, the boron content of a low-alloy steel reached 0·028 per cent by weight after the 800 hour treatment at 1500 deg. Fah.

Fig. 1 shows three heat-resistant alloy specimens coated with chromium-boron-nickel cermets at the Bureau. All three coatings were fired for four minutes at 1950 deg. Fah. in air. The coating represented by strip A contained Cr-B-Ni cermet powder only ; strip B contained 100 parts by weight of cermet powder and five parts clay ; while strip C contained ninety parts cermet powder, ten parts frit and five parts clay. True weld-

ing of the cermet to give a continuous metallic layer occurred only in the case of the coating containing frit. Reproduced in Fig. 2 are micrographs of three low-alloy steel specimens after long-time heating in air at 1500 deg. Fah. for a cermet coating evaluation. Specimen (a), which was uncoated, shows only a small amount of metal remaining after 400 hours of heating. The oxide layer and stringers under the coating on specimen (b) shows that the protection provided by the coating consisting entirely of ceramic material was not nearly as good as that obtained with the " M-60F " coating on specimen (c). Finally, Fig. 3 illustrates specimens of ingot iron coated respectively with plain ceramic coating and with " M-60 " coating after various times of heating in air at 1800 deg. Fah. The mottled appearance of the specimens coated with " M-60 " is caused by the non-uniform flaking of the thin scale layer that formed on the cermet coating surface during the heating.

Hydraulic Stretching and Detwisting Machine

A RANGE of high-production hydraulic stretching and detwisting machines for straightening both ferrous and non-ferrous metal sections has been developed by the Loma Machine Manufacturing Company of New York. Available in sizes from 7½ to 200 tons, the stretchers have been designed to handle extruded or rolled bars, tubes, structural shapes or sheet and strip. Individual lengths from 4ft to 100ft or more can be stretcher-levelled on these machines at high production rates. A representative machine of 50 tons capacity is illustrated in Fig. 1. An interesting aspect of the new stretchers is their optional availability with a special open tailstock, designed to allow the stock to protrude past the gripping jaws. Fig. 2 shows a tailstock of this special design. When using such a head, extrusions of varying lengths may be gripped and stretched without moving the tailstock every time or trimming the extrusions to uniform length. The new arrangement allows extremely fast loading and unloading of the machine and facilitates detwisting of shapes over only part of their total length. In such cases the tailstock is simply advanced toward the headstock until only the twisted portion of the extrusion is gripped, the remainder being allowed to protrude through the tailstock.

The Loma stretchers are completely self-contained machines having their oil-hydraulic power units conveniently mounted above the stretching cylinder. To facilitate rapid set-up for varying lengths, the tailstock has power-travel, and its anchoring pins are engaged or withdrawn by an air cylinder. The gripping jaws in both the headstock and tailstock are moved by air cylinders and controlled by conveniently mounted foot-operated valves, which leave the operator's hands free to handle the stock. The detwisting motion is applied to the headstock by a brake-motor driving through worm gearing, with rotation being unlimited in both directions.

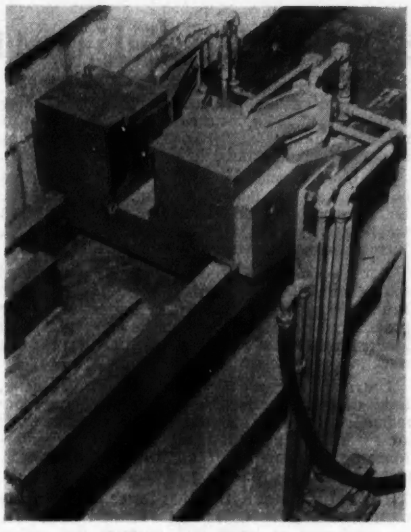


Fig. 2—Open tailstock of stretcher designed to allow stock to protrude past the gripping jaws

The headstock, which performs the stretching movement, is connected to the stretching cylinder by long tie bars and a cross-head attached to the end of the piston rod. The latter is of large diameter so that the displacement at the piston rod end of the cylinder is greatly reduced. This design affords favourable operating conditions : the full cylinder area becomes available for the generation of the stretching force, while for the movements in opposite direction high return speeds are automatically produced. The tie bars are supported by shoes sliding on the machined ways of the frame, thereby eliminating any possible deflection of the piston rod. The cylinder, thus, is protected against undue wear and requires very little maintenance. The oil-hydraulic power unit for the operation of the stretching cylinder comprises two pumps ; one low-pressure pump of large volume capacity, and one high-pressure pump of small output. During the cylinder movement involving small forces (take-up movement and idle return) both pumps supply oil to the cylinder for fast travel. As soon as pressure builds up in the cylinder at the start of the stretching process beyond a preset level, the low-pressure pump is idled and only the high-pressure pump operates. Whenever stock of relatively small section is to be processed, both pumps may remain engaged even during the stretching operation, to increase the output of the installation.

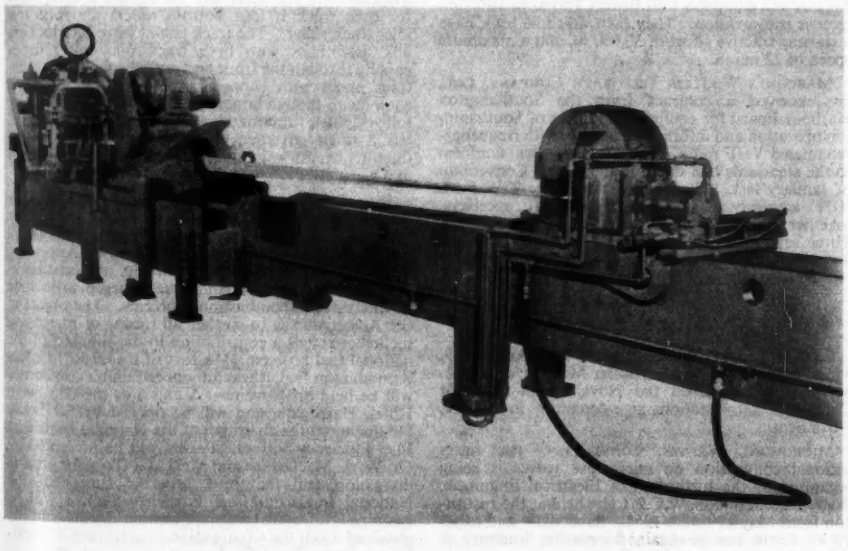


Fig. 1—50-ton hydraulic stretching and detwisting machine

Sintering Plant at Indiana Harbour

THE Inland Steel Company has contracted for the construction at its Indiana Harbour Works of a new sintering plant designed to expand its ironmaking capacity by 300,000 tons a year. The new plant will have twice the capacity of the company's present sintering facilities and will supply material to six of the company's eight blast furnaces, which have a combined pig iron capacity of 3,000,000 tons a year. The construction contract has been awarded to the Dwight-Lloyd Division of the McDowell Company. The plant will occupy about 12 acres of a new 20-acre extension to the steel mill property which was created by filling in Lake Michigan. The main building will be approximately 300ft long and 75ft wide. Moving grates 8ft wide, and with a total area of 1344 square feet, will be able to produce approximately 4000 tons a day of sintered ore.

American Research Reactor for Italy

A 50kW nuclear research reactor will be built by Atomics International, a division of North American Aviation, Incorporated, for the Centro Di Studi Nucleari Enrico Fermi of the Politecnico of Milan. The reactor will be used for research in radio-chemistry, materials and associated nuclear studies, and in connection with the university training programme. The reactor is a " solution-type " unit fuelled with uranyl-sulphate, enriched in uranium-235, in a water solution. The reactor has a completely enclosed gas-handling system which contains all radio-active products. The pile will be similar to the research reactors built for the Armour Research Foundation and for nuclear centres and universities in Japan, Denmark, West Berlin and Western Germany. The Japanese installation was completed in July, and the installations of the reactors for Denmark and Frankfurt University are now being completed.

10MeV Tandem Accelerator for Florida State University

THE proposed Florida State University nuclear radiation centre has announced that it will install a Van de Graaff tandem accelerator of 10MeV capacity. The new accelerator for physics research is to be manufactured by the High Voltage Engineering Corporation, of Burlington, Massachusetts, and the machine will be used with other specialised equipment in a scientific and educational programme aimed at training of nuclear engineers and technologists. The tandem accelerator is to be installed late in 1959 and will enable physicists to study the proton energy range from 5,000,000 to 10,000,000 electron volts, a region which, hitherto, has been studied only to a limited degree. The 35-ton machine consists of two 5MeV Van de Graaff particle accelerators placed end to end in a horizontal position, with a common high-voltage terminal. A steel pressure vessel, 8ft in diameter and 34ft long, houses the whole equipment.

Improved Teeth for an Excavator Bucket

AN increase of 5 to 25 per cent in the quantity of stone loaded by electric shovels working at a quarry, due to an improved form of tooth, is noted by the Marion Power Shovel Company, of Ohio. The teeth are broader than those normally fitted to the bucket of a face shovel, and only a narrow gap remains between adjacent teeth. The increased digging capacity, it is claimed, is due to increasing the capacity of the bucket by thus broadening the teeth ; two further advantages are claimed, namely, a reduction in the spillage of small stones from between the buckets' teeth and improved digging due to a " roller " action caused by side flanges on the teeth. In the quarrying work where these teeth have been used, buckets have been filled regularly with one pass of the digger arm.

Personal and Business

Appointments

MR. R. A. BROOKE has been appointed to the board of Holden and Brooke, Ltd.

MR. ROBERT L. CANNELL, A.M.I.E.E., has been appointed vice-principal at Loughborough College of Technology.

MR. G. N. PETTY has joined the Brush Export Organisation as area director for the Far East and Australasia.

LLOYD'S REGISTER OF SHIPPING announces that Mr. G. Buchanan has been appointed Assistant Chief Ship Surveyor.

MR. W. MCLELLAND has been appointed area sales manager, Scotland and north-east England, of A.P.V. Paramount, Ltd.

MR. DOUGLAS HALL has joined Low Moor Alloy Steelworks, Ltd., and Yorkshire Rolling Mills, Ltd., as general works manager.

SMALL ELECTRIC MOTORS, Ltd., has announced that Mr. N. Provand has been appointed to represent its Southern Scottish interests at 22, Pitt Street, Glasgow, C.2.

BRITISH TRANSPORT COMMISSION has announced the following appointments: Mr. S. C. Robbins, chief contracts officer at Commission Headquarters, and Mr. R. B. Hoff, chief supplies officer.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION has announced that Mr. E. A. Armstrong has been appointed controller of civil aviation ground services in succession to Sir Alfred LeMaitre, who is retiring on September 30, 1957.

MR. COLLIN J. ERSKINE has been appointed to succeed Mr. B. L. Scott as engineer-representative of George Ellison, Ltd., responsible for the sales and consultative service for high and low tension switchgear, motor control gear and hydraulic valves in Northern Ireland.

MR. G. SMELLIE of the Steel Company of Wales has been seconded by his company to the British Iron and Steel Federation to act as director of the British Iron and Steel Federation management courses, and Mr. H. I. Cozens has been appointed as deputy director of British Iron and Steel Federation management courses.

THE MINISTRY OF POWER announces the following appointments: Mr. W. A. Gallon, M.I.E.E., has been appointed as chairman of the South Wales Electricity board, and Mr. H. Pryce-Jones, M.I.C.E., M.I.E.E., has been appointed as deputy chairman of the South Wales Electricity board, and Mr. Robert James, M.I.Mech.E., has been re-appointed as a part-time member of the board.

A. REYROLLE AND CO., Ltd., has announced the following appointments: Mr. J. Christie, M.I.Mech. E., M.I.E.E., has been appointed a director; Mr. R. Wood, Hebburn works manager; Mr. R. B. Neary, new town works manager; Mr. F. W. Browell, erection manager; Mr. G. H. Hill, personal assistant to the general works manager; Mr. R. Rumbles, light engineering shop manager, and Mr. E. S. Blanch, welding shop manager.

Business Announcements

PETTER-MCLAREN SERVICE, Ltd., has announced that it is sending a mobile service team on a six-week tour of Europe.

THE BRITISH CENTRAL ELECTRICAL COMPANY, Ltd., states that it has opened a depot at Briticent House, Addlewell Lane, Yeovil, Somerset (telephone, Yeovil 2596).

INDUSTRIAL WASTE ELIMINATORS, Ltd., has been acquired by the Iwel Engineering, Ltd., a newly formed and wholly owned subsidiary of the Heenan Group, Ltd.

SOUTHERN INSTRUMENTS COMPUTER DIVISION, states that it has appointed Elesco Electronics, Ltd., 2, Fitzroy Place, Glasgow, C.3, as its exclusive agent for the whole of Scotland.

CHARLTON, WEDDLE AND CO., Ltd., Manor Works, Newcastle upon Tyne, 1, is a new company which has been formed to manufacture pipework for the marine and engineering industries.

WICKMAN, Ltd., has been appointed sole agent in the United Kingdom for the microfinishing machines manufactured by Maschinenfabrik Ernst Thielenhaus, Wuppertal-Barmen, Germany.

CLEVELAND METERS, Ltd., Redcar, has announced that, under a recent reorganisation, it has become a part of the international group of companies controlled by Neptune Meter Company, of New York, U.S.A.

KEITH BLACKMAN, Ltd., states that Norris Warming (Canada), Ltd., 640, Cathcart Street, Montreal, is its sole agent in Canada for "Tornado" fan engineering equipment, manufactured in London and Arbroath.

MR. C. H. DOBBIE, consulting engineer, states that he has taken into partnership Col. R. C. Graham, Dr. Pruschacinski and Mr. W. B. Harris, and that the firm is now C. H. Dobbie and Partners, 58, Victoria Street, Westminster, London, S.W.1.

COURTAULDS, Ltd., states that it has been decided to combine the company's acetate division with British Celanese, Ltd., who will be responsible for the production and marketing of acetate yarns, fibres and kindred products of the group, using its own existing trade marks as well as those of Courtaulds, Ltd.

UNITED CONSTRUCTION MACHINERY COMPANY, Ltd., states that it has been joined by three more manufacturers of contractors' plant, the companies are: Ruston-Bucyrus, Ltd., Lincoln; Millars Machinery Company, Ltd., Bishops Stortford; and Construction Machinery, Ltd., Wakefield.

THE BRUSH GROUP, Ltd., has formed a subsidiary company called the National Free Piston Power, Ltd., for marketing at home and overseas free piston gasifiers, manufactured by the National Gas and Oil Engine Company, Ltd., Mr. Donald Robson has been appointed executive director of the new company.

LLOYD'S REGISTER OF SHIPPING states that Mr. T. W. Bunyan has resigned his appointment as principal engineer surveyor for research. The society has also announced that its mobile team of investigating engineers has been constituted as an "Engineering Investigation Department," under the control of Mr. H. B. Siggers. Mr. G. P. Smedley has been appointed principal engineer surveyor for research on the chief engineer surveyor's staff.

Contracts

SHELL TANKERS, Ltd., has placed an order with The Decca Navigator Company, Ltd., for fitting forty-four of the company's oil tankers with Decca Navigator equipment.

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., has received an order from the New Zealand Ministry of Works for ten "International Drott" crawler tractor shovels.

SIMON HANDLING ENGINEERS, Ltd., has received through its Canadian company, Simon Engineering Companies of Canada, Ltd., contracts from the Canadian National Harbours Board, totalling over 1,000,000 dollars, for eight large pneumatic suction plants, six at Montreal Harbour and two at Quebec, to discharge bulk grain from ships' holds into storage in export granaries. The eight pneumatic plants will have a combined unloading rate of about 2500 tons of grain per hour.

YORKSHIRE ENGINE COMPANY, Ltd., Sheffield, a subsidiary of The United Steel Companies, Ltd., has received an order, valued at about £300,000, for the supply of twelve 400 h.p. "Janus" diesel-electric shunting locomotives to the Billingham Division of Imperial Chemical Industries, Ltd. The locomotives are powered by two 200 h.p. Rolls-Royce diesel engines and equipped with British Thomson-Houston electric transmission. They each weigh 48 tons, have a starting tractive effort of 30,000 lb, and a maximum speed of 22 m.p.h.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has received a contract from the Southampton Harbour Board for equipping the Port of Southampton operation and information service with frequency-modulated VHF radio. The equipment will conform to the standards laid down at the Hague Convention of January last. The order includes five 25W F.M. VHF transmitters and five F.M. VHF receivers, together with associated remote control equipment. Three seven-channel F.M. VHF mobile equipments and two automatic mains/stand-by engine-alternator sets are also among the items to be supplied.

Miscellanea

CANADIAN NAVIGATION CHAIN.—On August 19, Mr. George Hees, the Canadian Minister of Transport, officially opened the Nova Scotia chain of Decca Navigator stations at a ceremony in Halifax, Nova Scotia.

MICROWAVE VALVES CONVENTION.—An international convention on microwave valves is being organised by the Institution of Electrical Engineers, Savoy Place, London, W.C.2, to be held at the Institution from May 19 to 23, 1958. Particulars and registration forms can be obtained from the Secretary at the address given.

TOOL BITS.—A range of high-speed ground tool bits, hitherto manufactured in the United States, is now being made in this country by a British subsidiary of the Cleveland Twist Drill Company. These bits are made from molybdenum steel and are available in two grades, "Mo-Max" and "Mo-Max Cobalt." All bits are of square section, with a 10 deg. bevel on each end, and are made in sizes from ¼in square by 2½in long to 1½in square by 10in long. They are obtainable from E. P. Barrus (Concessionaires), Ltd., of Brunel Road, Acton, London, W.3.

NUCLEAR REACTOR STARTERS.—What is claimed to be the first commercial production in this country of neutron source tubes is being undertaken by the Talbot Stead Tube Company, Ltd., a subsidiary of Tube Investments, Ltd. The source tubes will be used to start the chain reaction in the two reactors at the Bradwell nuclear power station. (A source tube consists of an antimony rod surrounded by a beryllium tube and enclosed in a stainless steel sheath. Insertion in a working reactor "activates" the tube, i.e. causes the emission of γ-rays from the antimony, and these rays cause the release of neutrons from the beryllium.)

STRUCTURE AND PROPERTIES OF STEEL.—The British Iron and Steel Federation has produced three new instructional films dealing with the structure and properties of steel. The first of them explains how the grain structure and grain size of steel are affected by its carbon content, by the way in which it is shaped or worked, and the heat treatment to which it is subjected. The second film deals with the carbon content of steel and the third is concerned with different forms of heat treatment and how they govern the final properties of steel. The films, which have been made by Merton Park Studios, Ltd., are available in 16mm and 35mm; they are intended for use in works and classrooms in conjunction with other teaching aids produced by the Federation.

IMPROVED GRADES OF KIESELGUHR.—Five improved grades of calcined German Kieselguhr are now available from Charles H. Windschuegl, Ltd., 1, Leadenhall Street, London, E.C.3, U.K. suppliers of this material. The new grades are drawn from new deposits of fresh gur and it is claimed that they show an increase of up to 16 per cent in bulk volume, and an extended life cycle. Improvements have been made possible by the use of new quarrying techniques and the development of artificial methods of drying the gur, which, it is claimed, do not damage its intricate physical structure. Quarrying is therefore no longer dependent on the favourable weather conditions required for the original "Meiler" burning process, and regular supplies of consistent quality can be won throughout the year.

AGRICULTURAL CRAWLER TRACTOR.—Arrangements have been completed by International Harvester Company of Great Britain, Ltd., for the production at its Doncaster works of a 42 b.h.p. crawler tractor for agricultural use. The tractor is to be known as the "BTD-640," and its design follows that of the company's other crawler tractors, there being a one-piece main frame casting providing compartments for clutch, five-speed transmission, bevel gearing, and steering brakes and clutches. Three-point track suspension is provided, and the standard equipment for each track is four bottom rollers and one top idler track roller. The track chains have interlocking link assemblies with both track pins and bushes passing through the front and rear of each link; 12in track shoes with clipped corners are the standard equipment, though larger sizes will be available. The four-cylinder "International Harvester" diesel engine has a rated governed speed of 1450 r.p.m.; the tractor's five forward speeds are between 1·5 and 5·4 m.p.h.

FUEL EFFICIENCY.—At a conference held on Wednesday, September 11, details were given of the history of the Combustion Engineering Association, which was founded in 1933 as the Coal-Burning Appliance Maker's Association and assumed its present title in 1949, when the membership was enlarged to include all interested in combustion problems. The object of the Association is to further all means of increasing fuel efficiency as a contribution to the solution of the national fuel problem. As part of the effort to effect economies in fuel, it was announced that a conference will be held on November 5 and 6 at the Old Swan Hotel, Harrogate, and will be opened by Sir Leslie Hollinghurst, the chairman of the National Industrial Fuel Efficiency Service. Papers will be presented by Dr. W. A. Macfarlane and Mr. L. G. Clegg for general discussion, and the third progress survey of the National Industrial Fuel Efficiency Service will be examined. Details and application forms can be obtained from the Combustion Engineering Association, 6, Duke Street, St. James's, London, S.W.1.

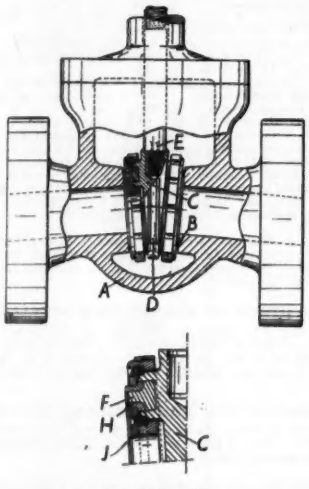
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

VALVES

781,122. June 16, 1955.—GATE-VALVES, G. Dikkers and Co. N.V., Hengelo (O), The Netherlands.

The invention relates to gate-valves with a wedge-shaped slide provided at one or both side faces with an annular recess in which a ring of rubber or like resilient material is located, this ring being broader at the base, thus leaving a space between the narrower part and the recess to accept a ring, to exert pressure on the base of the rubber ring. The invention has for its object to improve a valve in such a manner that the slide is adapted to seal against high pressures without detroying the rubber sealing ring or rings. As will be seen from the drawing, the casing *A* is provided with annular seats *B* on which the slide *C* has to seal. The slide has a groove *D* at each side of its circumference by means of which it is guided on ribs *E* projecting from the inner wall of the casing. As will be seen from the lower view, the slide body at each side face has an annular recess in which a ring *F*



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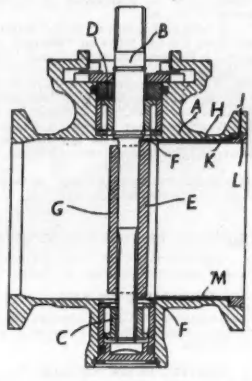
is located, the broader base of which fits in the recess. The rings may consist of synthetic rubber resistant to oil, water and gas. The ring at its narrow part is confined between two metal pressing rings *G* and *H*. The rubber ring is precompressed by a clamping ring *J* threaded into the slide and locked by a screw. A similar ring bears on the ring *H*. After compressing the rubber ring to the desired degree it still remains a little inside the outer edges of the pressing rings. The pressure exerted in the rubber ring is then equal to or somewhat larger than the pressure of the fluid against which the slide has to seal so that no fluid can penetrate between the ring and the walls of the recess in the slide. If, however, the slide is moved down in the casing between the seat faces, first the projecting pressing rings will come into contact with the seat faces. If the slide is moved further downwards the rings will increase the pressure exerted on the base of the rubber ring, whereby the rubber is extruded outwards until the ring is urged tightly against the seat face. As the rubber ring is now confined between the pressing rings and the seat face it behaves as a not or only slightly compressible material so that any further compression of the base of the ring results in a proportional extension of the narrow part of the ring. Complete sealing of the slide is therefore obtained even when impurities such as sand, clay or gravel are deposited on the seat face.—*August* 14, 1957.

781,183. July 20, 1954.—BUTTERFLY VALVES, Teddington Aircraft Controls, Ltd., formerly Teddington Controls, Ltd., Cefn Coed, near Merthyr Tydfil, South Wales. (*Inventor: Edward John Bush.*)

The invention relates to butterfly valves for controlling the flow of air and other gases and provides a valve construction having improved sealing properties when in the closed position. As shown in the drawing, the valve body or housing *A* is of the usual tubular form, and extending diametrically across it is a valve supporting spindle *B* mounted at its ends in bearings *C* and *D*. Secured on the spindle is a valve butterfly disc *E* having a radiused periphery *F* and provided on one face with a diametrically extending boss *G* formed with a splined hole to receive the spindle. Extending into the bore in the valve body and terminating closely adjacent the valve spindle is a thin-walled sealing sleeve *H*, preferably formed of stainless steel and approximately 0·008in thick. The sleeve has a rim *J* at one end clamped against a shoulder *K* in the valve body by the enlarged end portion *L* of a support sleeve *M*. The support sleeve extends inside the sleeve *H* over the greater part of its length. The



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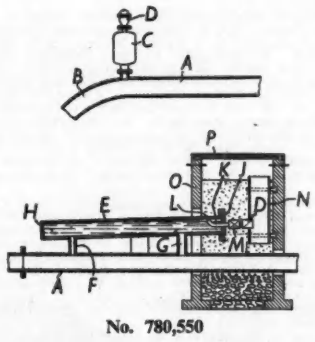
sealing sleeve is a loose fit between the support sleeve and the bore, and, being thin-walled, is deformable to a limited extent. The diameter of the butterfly disc *E* is slightly greater than the internal diameter of the sleeve *H* and when rotated into the mouth of the sleeve the disc makes an interference fit within it. The elasticity of the sleeve enables it to accommodate the necessary deformation and thus a gas-tight seal is obtained when the valve is in the closed position. The sleeve is mounted at the outlet side of the disc and, when the latter is in the closed position, gas pressure on the sleeve presses its mouth or rim on to the periphery of the disc and so further improves the sealing properties of the valve. An alternative construction is also described in the specification.—*August* 14, 1957.

PUMPS

780,550. September 5, 1955.—PUMPING PLANTS, Sulzer Freres, Societe Anonyme, Winterthur, Switzerland.

The invention relates to pumping plants of the kind having a pump which delivers water through a pressure pipe into a water container at a higher level than the pump, and a compensating container connected to the pressure pipe and provided with an air inlet non-return valve by which the interior of the compensating container can be put into communication with the atmosphere. In this case the compensating container is a length of pipe which is closed at both ends and which has the same diameter and the same wall thickness and consists of the same material as the pressure pipe and which is disposed above and substantially parallel to the pressure pipe. One of the pipes provided in constructing the plant can then be used as the compensating container. In one form of the invention the length of pipe is in communication with the pressure pipe at two points and is slightly inclined to the horizontal, and the non-return valve is connected to the higher end. Water then constantly



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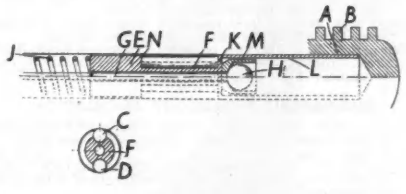
flows through the length of pipe during operation of the plant and does not remain stagnant for a relatively long time as in plants with a stand-pipe connected to the pressure pipe. By virtue of the inclination of the length of pipe the surface of contact between the water and the cushion of air is relatively small, so that little air is absorbed by the water. In the known form of pumping plant shown in the upper view a pressure pipe *A* on the left leads from a pump (not shown) and on the right passes to a water container (not shown) at a higher level than the pump. After its rise the pressure pipe has a bend *B* and then runs substantially horizontally to the water container. Beyond the bend, at a point where a negative pressure wave originating at the pump could cause a vacuum, there is connected a compensating container *C* with a non-return disc valve *D*. Air is let into the compensating container *C* through the check valve *D* only when the pressure in the compensating container falls below atmospheric owing to surge through the pipe. In the pumping plant embodying the invention and shown in the lower view, a length of pipe *E* is connected with the horizontal part of the pressure pipe *A* at *F* and *G* and is slightly inclined to the horizontal. Its length is such that it contains sufficient water to ensure that in the rare event of an exceptionally strong pressure wave passing through the pressure pipe only water will issue from it and not also the air above this water. This length of pipe *E* is closed at the left-hand end *H* and at the right end it is closed by a cover *J*. A pipe *K* passes through the cover, the inner end *L* of which is bent upwards. The pipe leads to a stop valve *M* and then to a non-return valve *D* through which the length of pipe *E* can be connected with an air shaft *N*. The parts are disposed in a concrete pit *O* filled with earth and covered with a lid *P*, which pit contains gravel at the bottom and through which the pressure pipe is conducted. This pit insulates the parts which it contains against cold.—*August* 7, 1957.

INTERNAL COMBUSTION ENGINES

781,441. March 20, 1952.—SAFETY DEVICES, F. C. Hibberd and Co., Ltd., Coronation Road, Park Royal, London, N.W.10, and Gilbert Ellesmere Potts, 25, Lulworth Gardens, South Harrow, Middlesex.

The invention relates to safety devices for internal combustion engines, more especially so-called flame-proofed diesel engines of tractors and light locomotives. Among the objects of the invention is to provide a device capable of automatically and rapidly stopping an internal combustion engine when conditions arise in which continued operation may become



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dangerous. The design shown in the drawing is intended more especially for immersion in the water exhaust trap of a flameproof diesel engine for a tractor. It comprises a housing *A* in the form of a sheath or tube adapted to be screwed laterally into the water tank of the trap and is finned at *B* to facilitate rapid heat transfer to the fusible pellets, of which two, *C* and *D*, are shown in the lower section. At *E* is a loaded member in the form of a plunger having an enlarged outer end which rides freely in the sheath *A*, and the plunger has a tubular shanked portion *F* passing over the end of a Bowden wire *G* provided with a retaining nipple *H*. The loading of the plunger *E* is provided by a coil compression spring *J*. The inner end of the spring *J* engages the outer end of the plunger *E* and the shanked portion *F* of the plunger is longitudinally grooved to mount the fusible pellets *C* and *D* which are solid cylinders and are maintained under longitudinal compression by the spring *J*. The inner ends of the pellets rest against a fixed abutment provided by the flanged end *K* of a sleeve *L* in the inner end portion of the sheath *A*. The inner end of the shank *F* on the plunger *E* abuts against the nipple *H* through a bell-shaped ferrule *M* surrounding the nipple and projecting through the mouth of the flange *K*. Under normal conditions the pellets *C* and *D* are compressed between the fixed flange *K* and the abutment *N* on the plunger *E* and prevent inward movement of the plunger and wire under pressure from the spring *J*. In the event of the water in the flame trap dropping below a predetermined safe level, the finned sheath *A* is immediately heated and thus causes melting of the pellets *C* and *D* with consequent inward movement of the plunger *E*. While this occurs the melted material of the pellets escapes out through ports formed in the plunger at the junction between its shank and abutment. Preferably the fusible pellets are of the material known as "Rose's Fusible Metal," having a melting point of 102·5 deg. Cent. ±5 deg. Cent., and suitable dimensions are 3in length by ½in diameter. A modified design is also shown in the specification.—*August* 21, 1957.

Launches and Trial Trips

REIN, oil tanker; built by the Netherlands Dock and Shipbuilding Company for Skips A/S Polarfront, Norway; length 213·50m, breadth 28·50m, deadweight 39,000 tons on 11·04m draught; four 1250 tons per hour centrifugal oil cargo pumps, three 150 tons per hour stripping pumps; three 550kVA, 60 c/s, 450V turbine-driven alternators, one 220kVA diesel-driven alternator; one set of two-stage turbines, 17,500 service s.h.p. at 98 propeller r.p.m., 19,250 maximum s.h.p. at 101 propeller r.p.m., two Babcock and Wilcox boilers supply steam at 600 lb per square inch and 800 deg. Fah. Launch, August 9.

CLAN MALCOLM, cargo liner; built by The Greenock Dockyard Company, Ltd., for the Clan Line Steamers, Ltd.; length between perpendiculars 465ft, breadth moulded 65ft 6in, depth moulded to upper deck 39ft 7¼in, deadweight 9760 tons on 27ft 3in mean draught, gross tonnage 7800; service speed 16½ knots; twelve passengers; three complete decks, five holds, bale capacity 572,000 cubic feet, one 80-ton, two 40-ton, two 15-ton, four 7-ton, ten 5-ton and two 3-ton derricks, sixteen electric winches; three 220kW, diesel-driven generators; Wallsend-Doxford opposed-piston oil engine, six cylinders, 750mm diameter by 2500mm combined stroke, 7500 b.h.p. at 103 r.p.m., arranged to burn heavy fuel. Trial, August 12, 13.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Sept. 20.—LIVERPOOL AND DISTRICTS BRANCH: Evening visit to John Summers and Sons, Ltd., Hawarden Bridge Steelworks, Shotton, Chester. ★ STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "Science and Responsibility," M. Pittock 7.30 p.m.

Sat., Sept. 21.—OXFORD, READING AND DISTRICTS BRANCH: Collier Lecture Room, Regent's Park College, Pusey Street, Oxford, "Electric Railway Signalling," 7 p.m.

Tues., Sept. 24.—S. WALES BRANCH: Angel Hotel, Westgate Street, Cardiff, General Secretary's Address, 7.30 p.m.

Thurs., Sept. 26.—S. LONDON BRANCH: Greyhound Hotel, High Street, Croydon, "A Talk on the Aims and Objects of the Association," E. A. Bromfield, 8 p.m.

ENGINEERING METROLOGY ASSOCIATION

Thurs., Sept. 26.—Northampton College of Advanced Technology, St. John Street, London, E.C.1, "Micro-Hardness Testing," R. Wall, 7 p.m.

Thurs., Oct. 24.—Northampton College of Advanced Technology, St. John Street, London, E.C.1, "The Millionth of an Inch and The Second of Arc," F. H. Rolt, 7 p.m.

ENGINEERS' GUILD

To-day, Sept. 20.—S. WALES AND MONMOUTHSHIRE BRANCH: Old Arcade Inn, Church Street, Cardiff, Luncheon, 12.45 p.m.

Thurs., Sept. 26.—METROPOLITAN BRANCH: Caxton Hall, Caxton Street, Westminster, London, S.W.1, Annual General Meeting, and Discussion on "The Aims and Future Policy of the Guild," 6 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Sept. 23.—BATH AND BRISTOL CENTRE: S.W. Electricity Board, Bath, Induction of Chairman, followed by Chairman's Address, 7 p.m. ★ LEICESTER CENTRE: Demonstration Theatre, E. Midlands Electricity Board, Charles Street, Leicester, Chairman's Induction and Film Show, 7 p.m.

Fri., Sept. 27.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, Chairman's Address, G. E. Kemp, 6 p.m.

Mon., Sept. 30.—LEEDS CENTRE: Griffin Hotel, Boar Lane, Leeds, Annual Dinner and Chairman's Induction, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Sept. 24.—GLASGOW BRANCH: Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, Joint Meeting with the Institution of Heating and Ventilating Engineers, "Steam," and "Combustion and the Chain Grate Stoker," 7.15 p.m. ★ S. WALES BRANCH: South Wales Engineers' Institute, Park Place, Cardiff, "Metal Degreasing by Trichloroethylene," and "Metal Pretreatment in Industry," 7.15 p.m.

Thurs., Sept. 26.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "The Design of Rolling Mills, with particular reference to Hot and Cold Ferrous Mills," M. Langen, 7.30 p.m.

Fri., Sept. 27.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Some Principles of Radiant Heating," P. A. Coles, 7.30 p.m.

Mon., Sept. 30.—W. AND E. YORKSHIRE BRANCH: Leeds University, "The Safe Use of Electricity," J. J. Emerson, 7.30 p.m.

Tues., Oct. 1.—GENERAL MEETING: Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "Reactor Plant Engineering," R. F. Jackson, 7 p.m. ★ E. MIDLANDS BRANCH: County Hotel, Theatre Square, Nottingham, "The Heat Pump: Some Aspects of its Application," J. A. Sumner, 7 p.m. ★ EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "Practical Plant Engineering in the Chemical Industry," C. W. Winstock, 7 p.m. ★ PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, "Hydro-Electric Power Development," G. C. Cummings, 7.30 p.m.

Wed., Oct. 2.—LEICESTER BRANCH: Bell Hotel, Leicester, "Factory Flooring," F. C. Harper, 7 p.m. ★ SOUTHERN BRANCH: Royal Beach Hotel, Portsmouth, "The Engineer and the Clean Air Act," E. C. Rogers, 7.30 p.m.

Tues., Oct. 8.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Chain Grate Stokers," C. H. G. Hayward, 7.15 p.m.

Thurs., Oct. 10.—GLASGOW BRANCH: Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, "The Measurement and Prevention of Smoke from Industrial Boilers," T. F. Hurley, 7.15 p.m. ★ MANCHESTER BRANCH AND MERSEYSIDE AND N. WALES BRANCH: Joint Meeting, Aboard Clubship "Landfall," "What Purpose does Incorporated Plant Engineers Serve?" 7.15 p.m. ★ N.E. BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "The Manufacture of Tubes," H. B. Elliot, 7 p.m.

Mon., Oct. 14.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Boiler Feed Systems and Auxiliaries," J. R. Cairns, 7.30 p.m.

Wed., Oct. 16.—KENT BRANCH: Kings Head Hotel, High Street, Rochester, "The Generation of Power from Atomic Energy," H. R. M. Hyder, 7 p.m.

Thurs., Oct. 17.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, "Man Management," A. Roberts, 7.30 p.m.

Fri., Oct. 18.—BIRMINGHAM BRANCH: Imperial Hotel, Lower Temple Street, Birmingham, Mobile Plant Discussion Group, "Planned Maintenance on Equipment on Building Sites," Walter T. Scopes, 7.30 p.m.

Tues., Oct. 22.—S. WALES BRANCH: South Wales Engineers' Institute, Park Place, Cardiff, Films on "Methods of Mechanical Application," "Reclamation of Oil," and "Conservation of Grade," 7.15 p.m.

Thurs., Oct. 24.—LONDON BRANCH: College of Preceptors, Bloomsbury Square, London, W.C.1, "Complexity of Plant and the Training of Operatives," N. D. Pirrie, 7 p.m.

Mon., Oct. 28.—WEST AND EAST YORKSHIRE BRANCH: Leeds University, "Thermoplastics, with particular reference to their Application in Tube Manufacture and Usage," J. Aldred, 7.30 p.m.

Thurs., Oct. 31.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "The Radar Telescope," H. C. Husband, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Sept. 25.—Constitutional Club, Northumberland Avenue, London, W.C.2, Presidential Address, A. Talbot, 7.30 p.m.

INSTITUTE OF FUEL

Wed., Oct. 9.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Symposium on "Flames and Industry," 10 a.m.

INSTITUTE OF METALS

To-day, Sept. 20.—Forty-ninth Annual Autumn Meeting, 1957 to be held in Glasgow.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., Oct. 3.—Royal Society of Arts, John Adam Street, Strand, London, W.C.2, Twelfth Annual General Meeting, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Oct. 1.—Great George Street, Westminster, London, S.W.1, "The Design and Construction of the Hindiya Bridge," J. F. C. Swansbourne, 5.30 p.m.

Tues., Oct. 8.—Great George Street, Westminster, London, S.W.1, "Investigation of Rainfall, Runoff and Yield on the Alwen-Brenig Catchments," W. K. Lewis, 5.30 p.m.

Tues., Oct. 15.—Great George Street, Westminster, London, S.W.1, "An Investigation into a Proposal to Dispose of Power Station Ash by Discharging it into the Sea at Low Water," F. L. Harwood and K. C. Wilson, 5.30 p.m.

Tues., Oct. 22.—Great George Street, Westminster, London, S.W.1, "Water Supply for the Yeovil District (Sutton Bingham Scheme)," R. C. S. Walters and R. J. C. Walton, 5.30 p.m.

Fri., Oct. 25.—Great George Street, Westminster, London, S.W.1, Graduates' and Students' Conversazione, 7.30–11.30 p.m.

Tues., Oct. 29.—Great George Street, Westminster, London, S.W.1, "Long Welded Rails in France," R. Levi, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Tues., Oct. 1.—E. MIDLANDS CENTRE: Loughborough College, Informal Conversazione and Reunion, 6.30 p.m. ★ N. MIDLAND CENTRE: Central Electricity Authority, Yorkshire Division, 1, Whitehall Road, Leeds, Chairman's Address, A. J. Coveney, 6.30 p.m. ★ N.W. CENTRE: Engineers' Club, 17, Albert Square, Manchester, Chairman's Address, F. R. Perry, 6.30 p.m. ★ S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, Chairman's Address, E. O. Taylor, 7 p.m.

Wed., Oct. 2.—S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Chairman's Address, E. O. Taylor, 7 p.m. ★ S. CENTRE: Central Electricity Authority, Portsmouth, Chairman's Address, L. G. A. Sims, 6.30 p.m.

Thurs., Oct. 3.—ORDINARY MEETING: Savoy Place, London, W.C.2, Inaugural Address as President, T. E. Goldup, 5.30 p.m.

Fri., Oct. 4.—N. SCOTLAND SUB-CENTRE: Robert Gordon's Technical College, Aberdeen, Chairman's Address, E. O. Taylor, 7.30 p.m.

Mon., Oct. 7.—E. ANGLIAN SUB-CENTRE: Assembly House, Norwich, Chairman's Address, "Education for Engineers," G. E. Middleton, 7.30 p.m. ★ MERSEY AND N. WALES CENTRE: Royal Institute, Colquitt Street, Liverpool, Chairman's Address, "Development of Electrical Services in a Soap and Chemical Factory," T. Makin, 6.30 p.m. ★ S. MIDLAND CENTRE: Grand Hotel, Birmingham, Chairman's Address, L. I. Tolley, and Annual General Meeting, and Conversazione, 6 p.m.

Tues., Oct. 8.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, Chairman's Address, "Meters and Meter Engineers," H. S. Petch, 5.30 p.m. ★ E. MIDLAND CENTRE: Loughborough College, Chairman's Address, J. D. Pierce, and Annual General Meeting, 6.30 p.m. ★ CAMBRIDGE RADIO AND TELECOMMUNICATION GROUP: Cambridgeshire Technical College, Chairman's Address, N. C. Rolfe, 6.30 p.m. ★ N.W. UTILIZATION GROUP: Engineers' Club, 17, Albert Square, Manchester, "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, 6.15 p.m. ★ N. IRELAND CENTRE: David Keir Building, Queen's University, Belfast, Chairman's Address, "Brief Review of the Progress of the Electricity Board for Northern Ireland," C. M. Stoupe, 6.30 p.m.

Wed., Oct. 9.—N.W. RADIO AND TELECOMMUNICATION GROUP: Engineers' Club, 17, Albert Square, Manchester, Chairman's Address, K. J. Butler, 6.45 p.m. ★ N. LANCASHIRE SUB-CENTRE: N.W. Electricity Board Demonstration Theatre, 19, Friargate, Preston, Chairman's Address, H. G. Cope, 7.15 p.m. ★ RUGBY SUB-CENTRE: Rugby College of Technology and Arts, Chairman's Address, W. J. Carfrae, 6.30 p.m. ★ OXFORD BRANCH: S. Electricity Board, 37, George Street, Oxford, "Visit of Electrical Delegation to Russia," D. F. Sayers, 7 p.m.

Thurs., Oct. 10.—UTILIZATION SECTION: Savoy Place, London, W.C.2, Chairman's Address, "Joints and Hinges," J. Vaughan Harries, 5.30 p.m. ★ N. MIDLAND CENTRE: Yorkshire Electricity Board, Ferensway, Hull, "A New Meter for the kVA Demand Charge," P. Baxter, 6.30 p.m. ★ W. WALES (SWANSEA) SUB-CENTRE: S. Wales Electricity Board Showrooms, The Kingsway, Swansea, Chairman's Address, I. G. Evans, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Oct. 14.—N.E. BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Building Structures," G. Gladstone, 7.15 p.m.

INSTITUTION OF ENGINEERS IN CHARGE

Wed., Oct. 9.—Caxton Hall, Caxton Street, Westminster, London, S.W.1, Forty-Fourth Annual General Meeting, 6.30 p.m.

Fri., Oct. 25.—Caxton Hall, Caxton Street, Westminster, London S.W.1, Presidential Address, Sir Harold Roxbee Cox, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Sept. 20.—LONDON BRANCH: Institution of Civil Engineers, Great George Street, London, S.W.1, "Pavement Construction on Christmas Island," V. J. M. Smith and R. Airey, 5.30 p.m.

Tues., Oct. 1.—E. ANGLIA BRANCH: Assembly House, Norwich, "Ordnance Survey," E. P. J. Williams, 6.30 p.m.

Thurs., Oct. 3.—YORKSHIRE AND LINCOLNSHIRE BRANCH: Technical College, Lincoln, "Control in the Manufacture and Laying of Bituminous Materials," H. G. Barnes, 7 p.m.

Fri., Oct. 4.—LONDON BRANCH: Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1. "Construction of Soil Cement Roads and Road Bases in Holland," F. A. Van der Sluis, 5.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 25.—GENERAL MEETING: Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Presidential Address, E. S. Cox, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Sept. 20.—N.E. GRADUATE SECTION: Visit from Tyneside to Calder Hall Atomic Generating Station.

Sat., Sept. 21.—N.E. GRADUATE SECTION: Visit to the Furness Shipbuilding Company, Ltd., Haverton Hill, Co. Durham.

Tues., Sept. 24.—GRADUATES' SECTION COVENTRY: Leofric Hotel, Coventry, "Industry, the Institution and the Engineer of the Future," A. G. Booth, 7.30 p.m.

Wed., Sept. 25.—S. BRANCH: Royal Aircraft Establishment Technical College, Farnborough, "Some Engineering Problems in Connection with the Industrial Application of Nuclear Energy," Sir Claude Gibb, 7.30 p.m. ★ YORKSHIRE BRANCH: Royal Victoria Hotel, Sheffield, "The Work of the Standards Engineer in Industry," H. Stafford, 6.30 p.m.

Thurs., Sept. 26.—E. MIDLAND GRADUATE SECTION: College of Art, Green Lane, Derby, Film Show, 7.15 p.m.

Tues., Oct. 1.—COVENTRY A.D. CENTRE: Leofric Hotel, Coventry, "The Suspension of Internal Combustion Engines in Vehicles," M. Horovitz, 7.30 p.m.

Wed., Oct. 2.—SOUTHERN BRANCH: Visit to the Atomic Energy Research Establishment, Harwell, 2.30 p.m., followed by "Patenting an Invention," C. Lees, 7 p.m.

Thurs., Oct. 3.—N.W. BRANCH: Engineers' Club, 17, Albert Square, Manchester, "Principles and Applications of Hydrodynamic-type Gas Bearings," G. W. K. Ford, D. M. Harris and D. Pantall, 6.45 p.m. ★ E. MIDLANDS GRADUATE SECTION: Grand Hotel, Leicester, "Some Highlights in the History of Mechanical Engineering," E. G. Sterland, 7.15 p.m. ★ YORKSHIRE GRADUATE SECTION: Grand Hotel, Sheffield, Ladies' Invitation Evening, "Mechanical Engineering in the Kitchen," 7.30 p.m.

Fri., Oct. 4.—BARROW-IN-FURNESS PANEL: Central College for Further Education, Lecture Theatre, Abbey Road, Barrow-in-Furness, "The Steam Catapult," C. C. Mitchell, and Q. H. Paterson, 7.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Oct. 17.—GENERAL MEETING: Geological Society, Burlington House, Piccadilly, London, W.1, "Control of Air Pressure as an Aid to Fight Mine Fires," J. M. Caw, and "The Production of Zinc in a Blast Furnace," S. W. K. Morgan, 5 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Oct. 10.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "Some Problems of Yacht Measurement," D. Phillips-Birt, 4.45 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., Sept. 24.—OXFORD SECTION: Town Hall, Oxford, "Transfer Pressing," 7.30 p.m.

Wed., Sept. 25.—SHREWSBURY SECTION: Shrewsbury Technical College, Shrewsbury, "British Clock and Watch Production," R. Lenoir, 7.30 p.m.

Thurs., Sept. 26.—NORWICH SECTION: Norwich City College, Ipswich Road, Norwich, "S.G. Iron—A Versatile Engineering Metal," W. W. Braidwood, 7 p.m.

Fri., Sept. 27.—LEICESTER SECTION: Grand Hotel, Leicester, "Work Measurement and Its Uses for Management," W. Hewett, 7 p.m.

Wed., Oct. 2.—N. MIDLANDS REGION: Victoria Station Hotel, Nottingham, "Principles and Applications of Pneumatics in Production," F. Kay, 7 p.m. ★ N.W. REGION: The Harris College of Further Education, Corporation Street, Preston, "The Production of Nuclear Fuels for the Atomic Power Programme," J. E. Littlechild, 7.30 p.m. ★ S.E. REGION: Mid-Essex Technical College and School of Art, Chelmsford, "Pride in Workmanship," Sir Gordon Russell, 7.30 p.m.

Thurs., Oct. 3.—MIDLANDS REGION: Craven Arms Hotel, High Street, Coventry: "Dynamic Balancing—A Growing Production Problem," J. Tye, 7.15 p.m. ★ MIDLANDS REGION: College of Further Education, Redditch, "Accurate Measurement in Engineering Production," J. Loxham, 7.30 p.m. ★ SOUTHERN REGION: Great Western Hotel, Reading, "Some Aspects of Automation," A. L. Stuchbery, 7.30 p.m.

Fri., Oct. 4.—Dorchester Hotel, Park Lane, London, W.1, Annual Dinner. ★ EASTERN REGION: Britannia Works Canteen, Davey, Paxman and Co., Ltd., Colchester, "Automation—Development of Transfer Equipment," A. J. Sephton, 7.30 p.m.

IRON AND STEEL INSTITUTE

Tues., Sept. 24.—4, Grosvenor Gardens, London, S.W.1, Autumn General Meeting, 10.45 a.m., to be followed by a Lecture at the Royal Institution, Albemarle Street, London, W.1, "The Future Engineering Development of the Gas-Cooled Nuclear Reactor," J. M. Kay, 6 p.m.

Wed. and Thurs., Sept. 25 *and* 26.—IRON AND STEEL ENGINEERS' GROUP: Church House, Westminster, London, S.W.1, "Air Pollution in the Iron and Steel Industry."

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., Oct. 10.—Mining and Technical College, Wigan, Annual General Meeting, 3.30 p.m.

ROYAL SOCIETY OF HEALTH

Thurs., Oct. 3.—WEYMOUTH SESSIONAL MEETING: St. John Hall, Westway Road, Weymouth, "Public Health Aspects of Atomic Energy," Katharine Williams, 10.30 a.m.

SOCIETY FOR WATER TREATMENT AND EXAMINATION

Wed. to Fri., Oct. 2 *to* 4.—Palace Hotel, Southend-on-Sea, Autumn Meeting.

SOUTH WALES INSTITUTE OF ENGINEERS

Tues. and Wed., Oct. 29 *and* 30.—Park Place, Cardiff, Centenary Celebrations.